POWER

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That Peak Load Problem

By Berton Braley

WE'VE rustled for power contracts and landed a lot as well,
We've hunted the country over for fancy outfits to sell,
We've peddled electric irons, we've boosted electric pots,
And gathered up fans and sold 'em in regular carload lots,
We've hinted and preached and threatened and advertised year on year
And talked to the folks like Uncles and written 'em plain and clear,
But in spite of our ceaseless efforts, our labors almost sublime
Full half of our power units are idle most of the time.

And that's the fault of peak load
(It never is a weak load)
Which jumps upon the backs of us at certain times of day
A bold and not a meek load,
A make-you-swear-a-streak load,
Oh, if it weren't for peak load our labor would be play.

THE sun goes down in the western sky and the stars come into sight,
And the homes of the busy city are drawing on us for light,
The theaters glow in glory, the signs and the street lights glare,
And here at the central station we've worry enough to spare,
For the straining boilers tremble, the laboring engines throb
And we start up the whole equipment to handle the heavy job,
It's trouble enough on week days to manage the problem well
And then when Saturday Night comes round—say, SATURDAY night is Hell!

And so we cuss the peak load
The big load, the freak load,
Which jumps upon the backs of us at certain times of day,
A strong and not a weak load
A make-you-swear-a-streak load,
Oh, if it weren't for peak load our labor would be play.

IF only the load were steady each hour of the twenty-four
We wouldn't be fretting and fuming and figuring any more
On boosting the "off hour" business by every kind of scheme;
But the peak load still is with us and life is no idle dream.
For all of the new inventions we've brought to the public's view
Electric curling irons and vacuum cleaners, too,
For all of our advertising, our urging in prose and rhyme,
Full half of our power units are idle most of the time.

And that's the fault of peak load
(It never is a weak load)
Which jumps upon the backs of us at certain times of day,
A not at all unique load
Yet, in a way, a freak load
Oh, if it weren't for peak load our labor would be play.

Washington Avenue Power Plant, Scranton, Penn.

By Warren O. Rogers

SYNOPSIS—This plant has been remodeled at a cost of $2,000,000. Six new water-tube boilers, each with 5580 sq.ft. of heating surface, have been installed. The generating units consist of three turbo-generators and two reciprocating engine-driven units, the latter exhausting to a district heating system during cold weather. Culm fuel having an average calorific value of 10,500 B.t.u. is burned in the boiler furnaces. This fuel has been through the washery twice and contains approximately 5.02 per cent. volatile matter, 74.98 per cent. fixed carbon and 20 per cent. noncombustible matter. At 163 per cent. of boiler rating 6.07 lb. of water is evaporated from and at 212 deg. in the old boiler plant. A test of one of the new boilers gives an evaporation of 8.38 lb. of water from and at 212 deg.

The City of Scranton, Penn., is situated in the heart of the Lackawanna Valley, one of the greatest anthracite producing regions in the country. The mines are dotted here and there all along the valley and range in size from those requiring 50 or 100 hp. in their operation up to those requiring from 2000 to 3000 hp. Many, in fact most, of these mines still use steam power and their electrification is for the future.

Naturally, in this region the greatest competitor of a central station is cheap coal, and in order to obtain and keep its business it must be in a position to sell electrical energy at an attractive rate and to give reliable service.

When the American Gas & Electric Co. took over the Scranton properties eight years ago, there were six companies supplying electric service from four generating stations to consumers, the combined yearly output of these plants being about 11,000,000 kw.-hr. Today the yearly output of the company generated in its two stations is more than 60,000,000 kw.-hr., which is distributed over 70 square miles, furnishing current to 16 cities and boroughs, ranging from 200 to 130,000 in population.

The old properties were becoming obsolete, and to meet the increasing business both for the present and for the

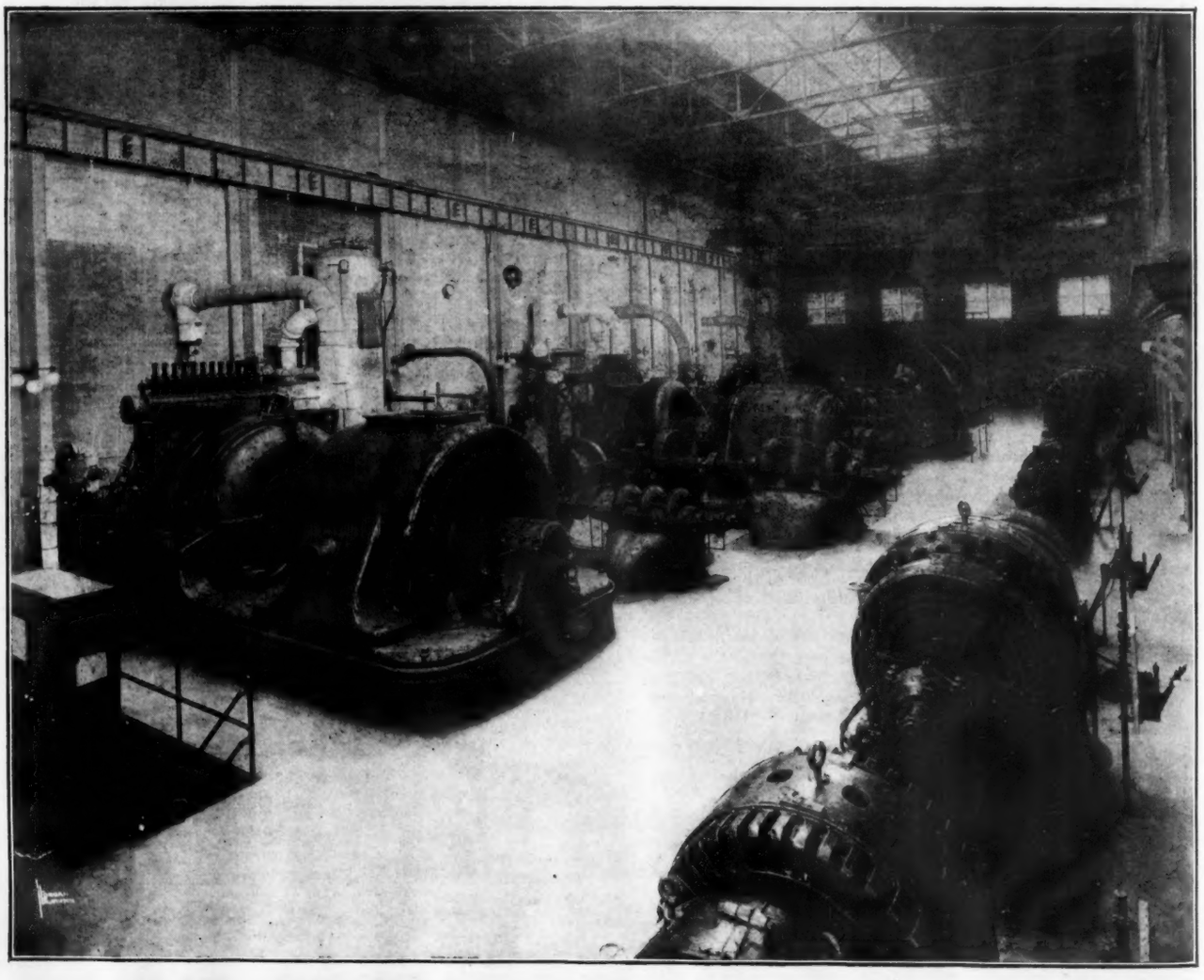


Fig. 1. General View of the New Washington Avenue Power Plant, Scranton, Penn.

future the suburban power plant on Washington Ave. has been rebuilt with the exception of the old boiler room. The new power house is 200 ft. long, 64 ft. wide and 37 ft. high to the steel roof trusses. The basement is 14 ft. 6 in. deep and contains the condensing apparatus. A new fireproof boiler house 120 ft. long, 115 ft. wide and 40 ft. high to the roof trusses, forms an ell with the old building.

The plant, before being remodeled, contained three 300-kw. alternating-current generators, two being belt-driven from two engines, from which alternating current was secured, and one was motor driven. These units were run separately with a total load of 1200 kw. The old station, with its belt-driven units, was typical of the old-time plant.

New Turbine Room

A view of the present turbine room is shown in Fig. 1, two of the three units being in the foreground. There are two Curtis-Rateau 10,000-kv.-a. horizontal turbo-generators and one 4500-kv.-a. unit, both generating current at 4000 volts. Two of the original 3500-hp. engines are retained. One, a cross-compound with cylinders 36&66x48 in., is directly connected to a 4000-volt, 2000-kv.-a. three-phase, 60-cycle alternator, and runs at 100 r.p.m. This engine is arranged to run condensing, to the atmosphere, or to exhaust into a heating system working against an average back pressure of 8 lb. The other reciprocating unit is a twin engine with cylinders 36x48 in., and runs at 100 r.p.m. It is directly connected to an alternator of the same size as that of the compound unit. This engine, which has been in service about four years, is designed to operate against a 40-lb. back pressure, as that was the pressure carried on the commercial heating system at the time it was installed. The weight of each flywheel is 65 tons.

The compound engine is piped to a surface condenser containing 6000 sq.ft. of cooling surface, or 1.7 sq.ft. per hp. The volute circulating and the hotwell pumps in the basement are turbine-driven. The 8x20x12-in. air pump is on the main floor. The condensers for the turbines are connected by expansion joints. The 10,000-kv.-a. turbine condenser has 20,000 sq.ft. of cooling surface, or 2.66 sq.ft. per kw. The condenser for the latest 10,000-kw. turbine installed is of the usual design, but it has a special arrangement of the tubes. It contains 30,000 sq.ft. of cooling surface, or 3 sq.ft. per kw. of turbine capacity. That for the 4500-kv.-a. unit has 11,000 sq.ft. of cooling surface, or 2.7 sq.ft. per kw.

The 20- and the 28-in. triplex volute circulating pumps for both condensers are turbine driven, and are on the main floor, as are also the 12x30x16-in. and the 8x20x12-in. dry-air pumps for the 10,000- and the 4500-kv.-a. units. A vacuum within 2 in. of the barometer is maintained with injection water at 70 deg., and within 3 in. at 80 deg. F.

Circulating water flows to the pumps by gravity from eight cooling towers at the rear of the plant and 50 ft. above the basement floor. The return water is through a 42-in. diameter cast-iron pipe, and is controlled by motor-driven valves.

Cooling Towers

The cooling towers, Fig. 2, are of the combination fan and natural-draft type. They are built over a covered concrete reservoir with concrete columns extending above the reservoir on which the towers rest, and leaving openings between the columns for the entrance of air when the towers are operated on the stack-draft principle. The air spaces below the towers are separated by concrete aprons extending from the under side of the top of the reservoir down to a point below the water level, thus making each tower independent of the others, so far as operation is concerned. The stacks are built of sheet steel riveted and are cylindrical in form, the lower parts being 24 ft. in diameter and the towers 70 ft. high from the top of these supporting piers.

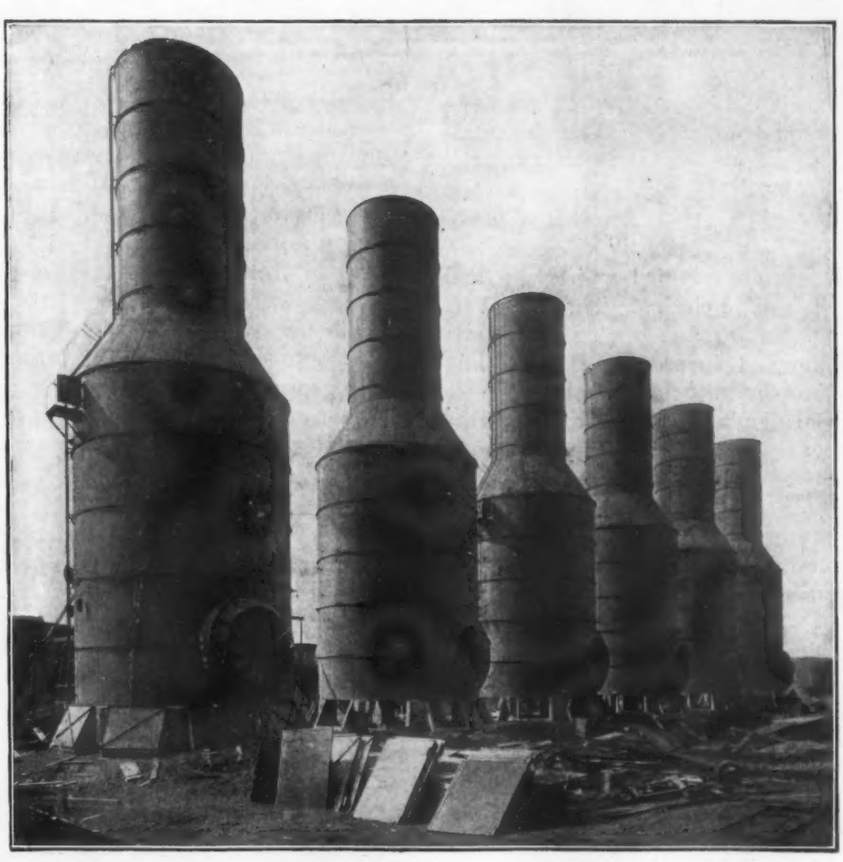


Fig. 2. Combined Fan and Natural-Draft Cooling Towers

Each tower is provided with two 10-ft. diameter fans mounted on one shaft and driven by a motor in a concrete housing close to the tower. The cooling surface consists of dressed cypress boards set on edge, each course being arranged at right angles to the course below.

Warm circulating water is brought to each tower through a 14-in. discharge pipe entering at a point just above the fans and extending up through the center of the tower to a point just over the cooling surface. On the top of this discharge pipe is a self-rotating water distributor, which is revolved by the reaction of the jets of

circulating water and rotates on a lignum-vitæ bearing which, being lubricated by a part of the circulating water, requires no attention.

The special openings between the supporting piers at the base of the tower are provided with steel doors hinged

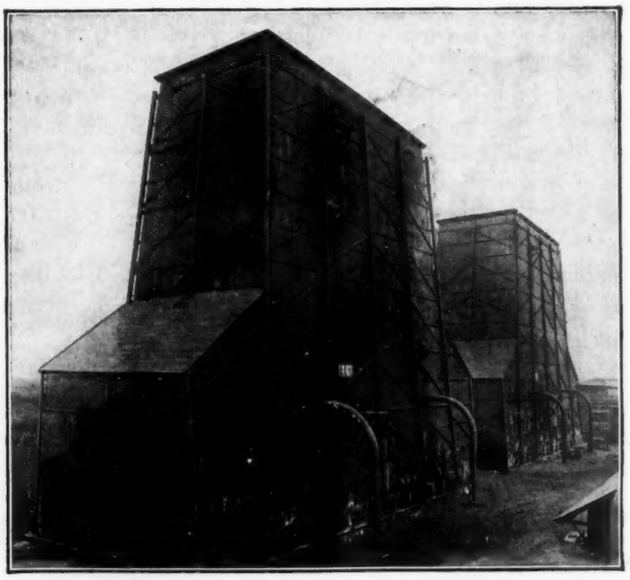


FIG. 3. TWO COOLING TOWERS, CAPACITY 5000 GAL. PER MIN.

at the top and partly counterweighted with chain and weight to facilitate opening and closing. The lower part of the tower can be entered through one of these draft doors, and the distributor and upper part of the cooling surface are accessible through a door arranged at the side of the stack. A ladder extends from the ground to the top of the tower, passing close to the platform in front of the upper opening.

This battery of towers is capable of cooling the circulating water from the condensers serving a power plant of 14,500 kw., when maintaining a vacuum within 3 in. of the barometer, and during summer weather conditions with forced draft.

In cold weather, or when the load on the power station is light, the fans are stopped, the draft doors are opened and the towers allowed to operate on a stack-draft principle, thus saving the power necessary to operate the fans.

There are also two natural-draft cooling towers working in connection with a 10,000-kw. turbine. These towers are shown in Fig. 3. They are about 250 ft. long, and 100 ft. high, and are of the all-wood natural draft type, built under a license from the Balcke Co. of Germany. So far as known, these are the largest natural-draft cooling towers installed in the United States.

The condensate and circulating pumps are mounted on a single bedplate and driven by a steam turbine through a common shaft. Fig. 4 shows the unit in part. The pump *A* is a combined hydraulic-air and condensate pump. There is but one connection to the condenser—the condensate and non-condensible vapors being separated in this pump. In case the hurling water used in the air pump becomes too hot it can be cooled by city water.

The centrifugal circulating pump *B* is of standard type. An interesting fact concerning this installation, as shown by the readings for a day herewith given, is that the vacuum is better than 29 in. practically throughout. It is understood that this showing is a record in this country, and there are no data available from foreign plants showing such results. The readings are as follows:

SCRANTON ELECTRIC COMPANY Feb. 25, 1915

Time	Load, Kw.	Circ. Inlet	Circ. Outlet	Condensate	Temp. Atmos.	Humidity	Corrected Vacuum	Hurling	Cooler Inlet	Cooler Outlet	Water In	Water Out	Speed Pump
12:	3400	55	63	60	38	..	29.24	50	51	38	50		1500
1:	2600	53	59	57	36	..	29.25	48	48	38	48		1500
2:	2000	51	56	53	36	..	28.25	46	47	38	47		1500
3:	800	49	52	51	36	..	29.44	46	47	30	47		1500
4:	800	46	48	47	36	..	29.48	45	46	off			1500
5:	800	44	46	45	34	..	29.48	47	47	off			
6:	3200	46	53	48	32	..	29.48	49	50	38	50		
7:	3800	50	58	58	32	..	29.25	47	48	38	50		
8:	4000	52	61	57	35	70	29.3	50	51	38	50		
9:	5600	55	64	61	32	70	29.24	54	56	38	53		
10:	4800	55	65	62	34	70	29.24	58	58	38	57		
11:	4800	56	66	63	34	70	29.29	55	56	38	56		
12:	5600	57	62	64	36	70	29.20	55	56	38	55		
1:	6000	56	66	63	36	70	29.24	53	54	39	53		
2:	5400	57	67	64	36	..	29.19	58	59	38	57		
3:	5400	57	67	67	35	..	29.19	58	59	38	50		
4:	6000	59	70	68	35	..	27.14	53	55	38	48		
5:	6000	58	69	67	35	70	29.19	50	52	38	48		
6:	5200	57	68	65	32	..	29.20	48	50	38	47		
7:	8000	59	78	70	30	..	29.1	51	53	39	49		
8:	8000	59	75	72	30	..	29.05	52	55	39	49		

The combined condensate and turbo air pump* is driven by the same auxiliary turbine that drives the circulating pump. This arrangement is compact and requires less attention than the general arrangement of condensing apparatus. The exhaust steam from the pump turbine is connected to the second stage of the 10,000-kw. turbine. The exhaust pipe from the pump turbine is fitted with an automatic trip throttling valve close to the connection to the large turbine. There is also a back pressure valve set at 15 lb. pressure absolute. The pressure in the first stage of the turbine is 30 lb. and that of the second stage is 13 lb. absolute, therefore the exhaust steam enters the second stage of the large turbine at a pressure of 2 lb. above that existing in that

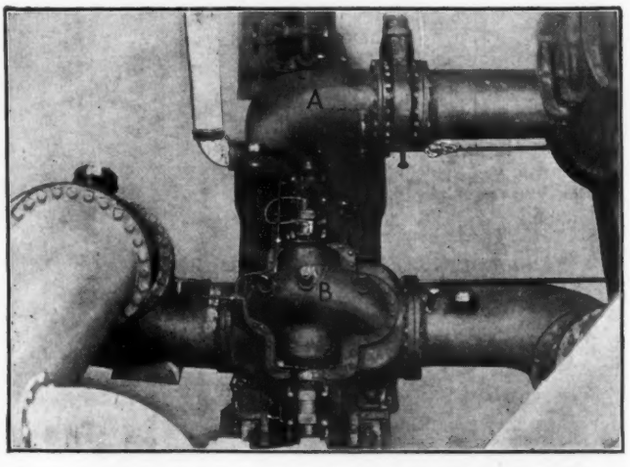


FIG. 4. TURBO-AIR AND CONDENSATE PUMP ON SHAFT WITH CIRCULATING PUMP

portion of the turbine. In the near future the exhaust steam from the other turbine auxiliaries will be connected to their respective turbines and the exhaust steam used in the second stage.

The makeup water is taken from the city water mains. The feed water is taken from one 4000-hp. open

*Details of a test of one of these air pumps were published on page 442 of the Mar. 30, 1915, issue.

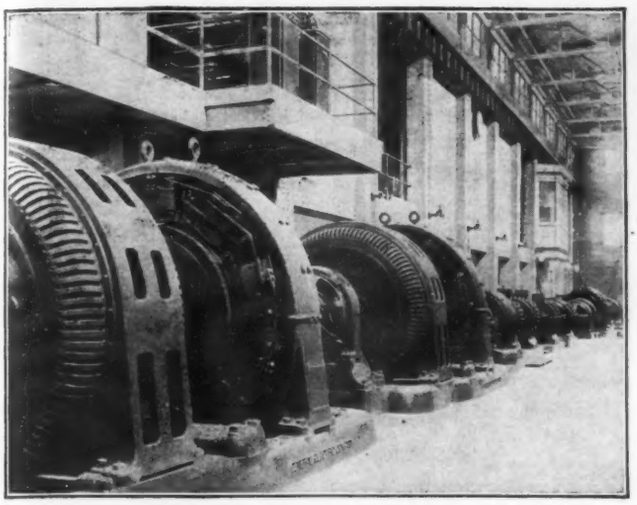


FIG. 5. A LONG LINE OF MOTOR-DRIVEN UNITS

heater by two 16x10x18-in. outside-packed pumps controlled by a pump governor and from one 5000-hp. heater by two 500-gal. capacity centrifugal boiler feed pumps. Exhaust steam from the auxiliaries is used for heating the feed water, all, with two exceptions, exhausting into a common header. The circulating pumps on the 10,000-kv.-a. turbine units are arranged to run either condensing or noncondensing, assuming that with both main turbines in operation more than enough exhaust steam would be obtained for feed-water heating.

AUXILIARIES

Along the switchboard side of the turbine room is a row of motor-driven units, shown in Fig. 5, consisting of the following:

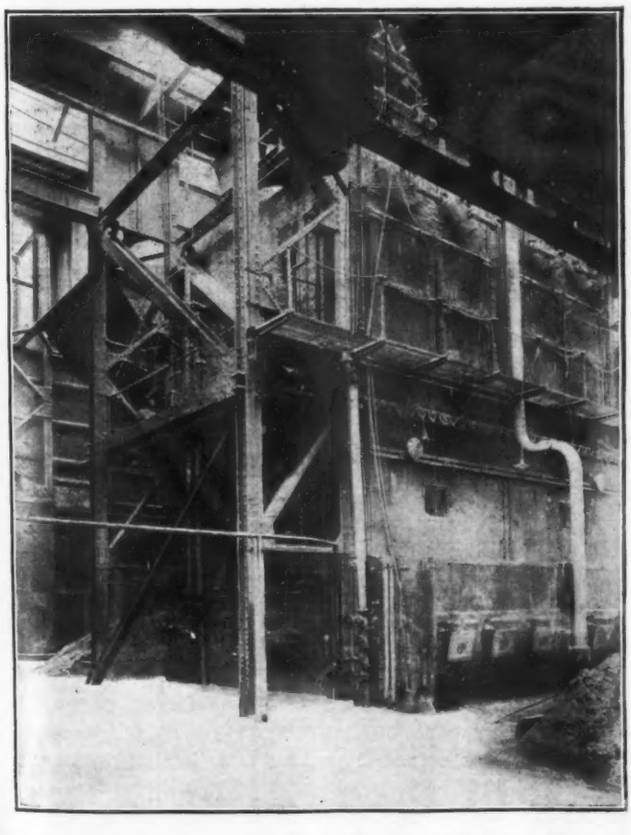


FIG. 6. ONE OF THE NEW DOUBLE-DECK BOILERS

Two 1400-hp. synchronous motors directly connected to two 1000-kw., 550-volt railway generators, speed 514 r.p.m. These units have a 125-volt exciter mounted at one end of each shaft.

Two 250-hp., 4000-volt synchronous motors, each directly driving three 6.6-amp. arc-light machines at 514 r.p.m.

One 186-hp., 4000-volt synchronous motor directly connected to two 6.6-amp. arc-light machines at 514 r.p.m. motor circuits.

One 150-hp. induction motor driving 100-kw., 250-volt, direct-current generator at 580 r.p.m.

One 300-hp. induction motor driving a 200-kw., 250-volt, direct-current generator at 580 r.p.m.

There are three exciter units: One is a 150-kw., turbine-driven set generating 125-volt direct current at 3775 r.p.m.; one is an induction, 250-hp. motor-generator set generating 125 volts at 720 r.p.m.; and the third is a 10&18x10-in. marine engine directly coupled to a 150-kw., 125-volt, direct-current generator, at 340 r.p.m.

BOILER ROOM

The old boiler room contains only water-tube boilers, of which four are of 480-hp. capacity, four 600-hp., and

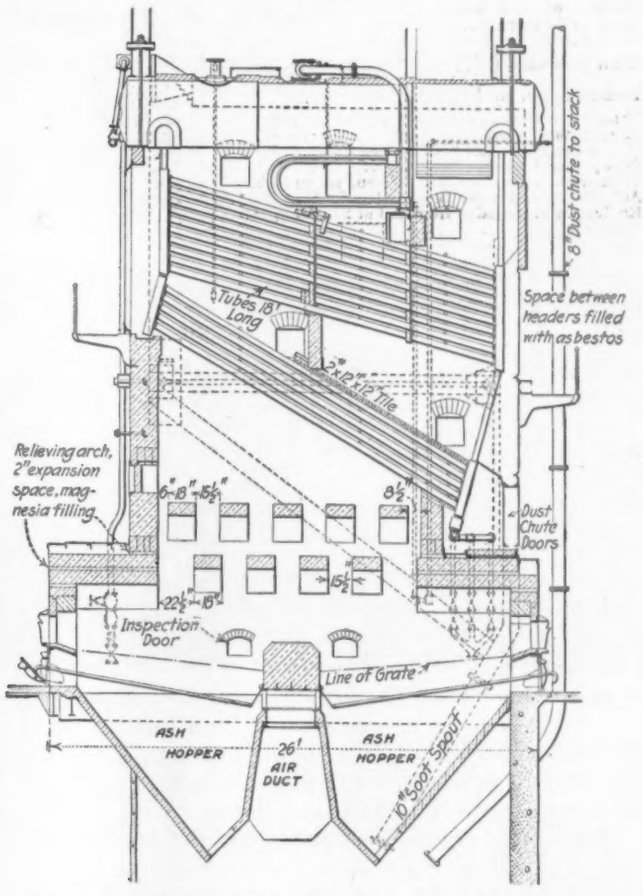


FIG. 7. SECTION THROUGH ONE OF THE BOILERS

five 300-hp. The eight largest are equipped with dutch-oven furnaces and dumping grates. The five small ones have shaking grates. All are equipped with regulators, and but two have superheaters.

In the new room, Fig. 6, there are six special-type, double-deck, water-tube boilers with two banks of 18-19-ft. tubes, each 18 sections wide; the upper one is 10 and the lower 5 tubes high. These boilers are double-end and are at present hand fired. Mechanical stokers are to be installed in the near future capable of handling the grade of fuel now being burned. Each boiler contains 5580 sq.ft. of heating surface and is rated at 558 hp. The grate surface is 217 sq.ft., which gives 2.57 sq.ft. of heating surface per square foot of grate surface. Washed buckwheat and anthracite culm are used.

Fig. 7 is a section through one of the new boilers. Forced draft is used, the main air duct being between

Following are the results of tests recently run on two of these boilers:

BOILER TESTS AT THE WASHINGTON AVENUE PLANT

Boiler: Babcock & Wilcox W.S.V.H. Special. 18 Sections, 10 High, 18-ft. Tubes. 18 Sections, 5 High, 19-ft. Tubes. Two 42-in. Drums—5580 sq.ft. H.S.-Rating 558 hp. Babcock & Wilcox Superheater—Furnace Double End. Hand-fired. 217 sq.ft. G.S.
Coal: Washed Buckwheat No. 2—Slush—Bituminous—"Shawmut."

		Aug. 19, 1914	Aug. 21, 1914	Aug. 24, 1914	Aug. 25, 1914	Aug. 27, 1914	Aug. 28, 1914
Date							
Duration	Hr.	8.07	8.00	8.17	8.00	8.00	8.00
Kind of coal		Washed	Slush	10% soft—90% slush	70% washed—30% slush	10% soft—90% washed	Washed
Steam pressure	Lb.-Sq.In.	156.00	155.00	154.00	157.00	158.00	158.00
Temperature superheated steam	Deg. F.	437.20	439.90	445.70	445.00	441.60	437.80
Degrees superheat	Deg. F.	68.30	71.40	77.70	75.60	71.70	67.90
Temperature feed	Deg. F.	64.00	65.50	65.00	65.30	65.00	65.00
Factor of evaporation		1.2408	1.2408	1.2447	1.2437	1.2420	1.2399
Total water	Lb.	237,523	173,634	214,563	226,173	306,720	285,960
Total water from and at 212 deg.	Lb.	294,719	215,445	267,067	281,291	380,946	354,618
Water per hour from and at 212 deg.	Lb.	36,520	26,931	32,689	35,161	47,618	44,320
Total coal fired	Lb.	41,793	45,600	48,400	51,960	50,400	48,800
Per cent. moisture	Per Cent.	9.50	16.35	16.47	12.79	8.49	7.56
Total dry coal	Lb.	37,823	38,122	40,429	45,314	46,121	45,111
Total ash and refuse as weighed	Lb.	11,351	14,941	13,092	17,039	12,089	12,066
Moisture in ash and refuse	Per Cent.	1.24	0.12	2.86	0.24	0.66	0.20
Total dry ash and refuse as weighed	Lb.	11,210	14,923	12,729	16,998	12,009	12,042
Ash and cinder from roof	Lb.	128	406	501	549	500	494
Total ash and cinder figured from coal and ash analyses	Lb.	280	1,377	1,540	1,602	665	1,035
Total dry ash and refuse	Lb.	11,490	16,300	14,269	18,600	12,674	13,077
Total combustible	Lb.	26,333	21,822	26,160	26,714	33,447	32,034
Per cent. of ash from test	Per Cent.	30.38	42.76	35.29	56.74	27.48	28.98
Draft at damper	In. of H_2O	0.43	0.53	0.50	0.52	0.55	0.49
Draft bottom first pass	In. of H_2O	0.04	0.06	+0.01	+0.01	+0.03	+0.01
Draft in furnace front	In. of H_2O	0.14	0.12	0.08	0.06	—0.02	—0.06
Draft in furnace rear	In. of H_2O	0.15	0.12	0.09	0.09	—0.02	0.07
Pressure in ash pit front	In. of H_2O	1.46	2.09	1.88	2.68	1.83	1.74
Pressure in ash pit rear	In. of H_2O	1.41	1.81	1.87	2.46	1.82	1.65
Temperature flue gases	Deg. F.	513	485	511	520	544	535
Temperature room	Deg. F.	91	84	84	80	82	80
Coal per sq.ft. g.s. per hour as fired	Lb.	23.98	26.39	27.43	30.07	29.17	28.24
Coal per sq.ft. g.s. per hour, dry	Lb.	21.70	22.06	22.91	26.22	26.69	26.11
Water from and at 212 deg. per hour per sq.ft. h.s.	Lb.	6.50	4.80	5.90	6.30	8.50	7.90
Actual evaporation per lb. of coal as fired	Lb.	5.68	3.81	4.43	4.35	6.09	5.86
Equivalent evaporation from and at 212 deg. per lb. dry coal	Lb.	7.79	5.65	6.61	6.21	8.26	7.86
Equivalent evaporation from and at 212 deg. per lb. of combustible	Lb.	11.19	9.87	10.21	10.53	11.39	11.07
Horsepower developed		1058.50	780.6	947.50	1019.10	1380.20	1284.60
Per cent. rating	Per Cent.	189.70	139.90	169.80	182.60	247.30	230.20
Efficiency dry coal basis	Per Cent.	65.54	52.57	61.56	57.71	66.61	64.79
Efficiency combustible basis	Per Cent.	76.19	67.48	70.27	71.99	76.07	74.59
Gas analysis CO_2	Per Cent. Vol.	12.00	9.10	10.20	9.70	13.20	13.00
O_2	Per Cent. Vol.	7.50	10.70	9.40	9.40	6.40	6.70
CO	Per Cent. Vol.	0.00	0.00	0.00	0.00	Trace	Trace
N_2	Per Cent. Vol.	80.50	80.20	80.40	80.90	80.40	80.30
Coal analysis moisture	Per Cent.	9.50	16.35	16.47	12.79	8.49	7.56
Volatile matter	Per Cent.	8.98	9.60	11.87	9.34	10.05	9.44
Fixed carbon	Per Cent.	71.94	63.88	62.03	64.22	72.77	72.30
Ash	Per Cent.	19.08	26.52	26.10	26.44	17.18	18.26
B.t.u. dry coal		11,533	10,430	10,420	10,441	12,034	11,772
B.t.u. combustible		14,252	14,194	14,100	14,194	14,530	14,401
Ash analysis moisture	Per Cent.	1.24	0.12	2.86	0.24	0.66	0.20
Volatile matter	Per Cent.	1.96	2.56	2.00	1.24	1.12	2.64
Fixed carbon	Per Cent.	36.16	38.92	27.20	37.70	38.44	39.06
Ash	Per Cent.	61.88	58.52	70.80	61.06	60.44	58.30

the ash hoppers and opening to a blast box which is equipped with hand-operated dampers for controlling the volume of air admitted below the grates. The staggered arches are 18 in. wide and spaced 15½ in. This arrangement is to provide a baffling which, with its high temperature, will cause the furnace gases to burn before striking the comparatively cool tube surface; also, to diffuse the heat currents so that they will reach the heating surface of the lower bank of tubes from end to end.

This method of arch construction has developed trouble in that the arches have been found difficult to keep in place. To preserve them in place a pillar 2x4 ft. in size has been built between the bridgewall and an arch 11 ft. long, 9 ft. high and 6 ft. cross-section, and arched 15 in. at the center. This arch replaces the bottom one, Fig. 7, and the brick column has proved satisfactory. The six new boiler furnaces will be so equipped.

Resting on the top row of the lower bank of tubes is a tile baffle wall, which extends 10 ft. 9 in. from the lower end of the tubes. The upper bank is baffled for three passes of the gases, the superheater being placed between the first and second pass.

In order to facilitate cleaning the space between the two banks of tubes, provision has been made to remove the dust to the ash hopper through a 10-in. dust chute. Dust from the stack is taken care of by an 8-in. chute which is brought down to a point convenient for discharging into a tile drain running to the ash accumulating pit.

The capacities secured in the tests are interesting in view of the poor quality of coal used, and this is also true of the efficiencies. Heat balances which have been worked out from three of these tests show the following results:

	Date		
	Aug. 19	Aug. 21	Aug. 28
Heat absorbed by boiler	65.54	52.57	64.79
Loss due to moisture in coal	1.02	1.92	0.80
Loss due to burning hydrogen	2.35	2.71	2.34
Loss due to chimney gases	11.31	11.71	10.91
Loss due to moisture in air	0.54	0.33	0.46
Loss due to incomplete combustion	0	0	0
Loss due to carbon in ash	14.62	25.22	15.18
Loss due to radiations, etc.	4.62	5.44	5.52

Air assumed to have 60 per cent. saturation in all cases.

Air for the forced draft in the old boiler room is supplied by two 14-ft. and one 10-ft. steel-plate blowers and in the new boiler room by two turbo- and one motor-driven fan. Ashes and soot in the old boiler room are removed and discharged into a tank 70 ft. above the basement floor, by means of a 5-ft. exhaust fan which runs at a speed of 1440 r.p.m. and is driven by a 100-hp. motor.

Ashes from the new boilers are dumped from the hoppers into half-round tile drains in which they are flushed by mine water into a pit, from which they are taken by a crane and loaded into railroad cars (Fig. 12).

An interesting method of getting rid of ashes from this plant was used about two years ago. As is well known, under the City of Scranton are many coal mines that have been worked out to a large extent, and this power plant is over a mine, the top vein of which is about 130 ft. below the surface. Pillars had been left to support the roof.

FIG. 8. CULM BANK AND SCRAPER CONVEYOR

huge piles is being reclaimed by passing it through washeries, and is sold in the market in the various sizes of buckwheat. The fine dust, dirt and bone were looked upon as of no particular value, and in some cases were discharged to any stream handy or returned to a bank for rewashing.

The fuel used at the Scranton suburban plant has been through the washing process twice and is so fine that a dry sample taken from the bank and passed through a $\frac{7}{16}$- and over a $\frac{1}{4}$-in. mesh screen gives 8 per cent.; through a $\frac{3}{8}$-in. and over a $\frac{1}{8}$-in. mesh, 6 per cent.; through $\frac{1}{8}$-in. mesh, or dust, gives 76 per cent.. An approximate analysis showed volatile combustible matter 5.02 per cent., fixed carbon 74.98 per cent., noncombustible matter 20 per cent., and a calorific value of 10,500 B.t.u.

This fuel is so fine and dust-like that it is necessary to thoroughly wet it before firing to prevent its being carried over back of the bridgewall before it has had a chance to become completely ignited.

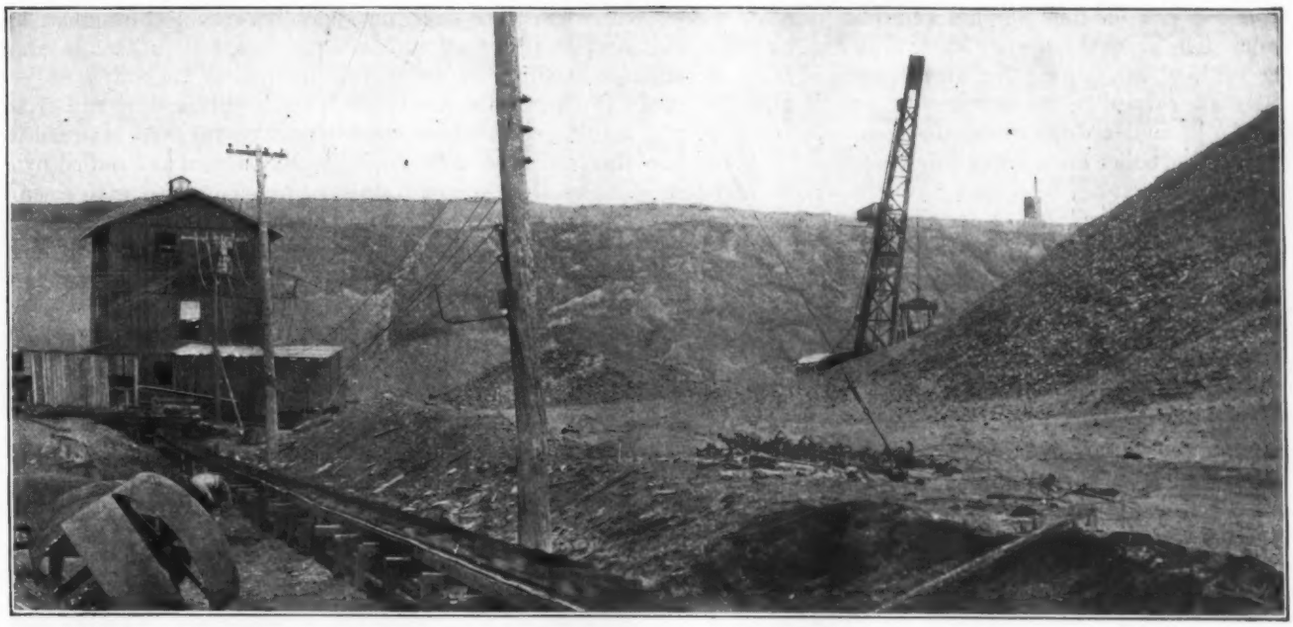


FIG. 9. CULM BANK, ELECTRICALLY OPERATED JIB CRANE AND CRUSHER HOUSE

To prevent the ground from settling under the plant, two 8- and one 10-in. bore holes were drilled through to the three veins, which were worked out, and the ashes from the boilers were flushed into the chambers and passages; thus making a solid support for the plant.

It is proposed to return to this method of ash disposal as the company has about 30 acres of mine surface which is available for filling in. A bore-hole will be drilled in one corner of the ashpit and the ashes flushed to the abandoned mine. There will also be an ash-storage tank of a size to hold about six days' ash accumulation. This is so that the contents of the ash basin and that of the bin can be sent to the mine at one flushing and so decrease the labor cost, as it is necessary to employ men at the outlet of the flushing pipe. It is estimated that with this arrangement one man will do the work formerly performed by six.

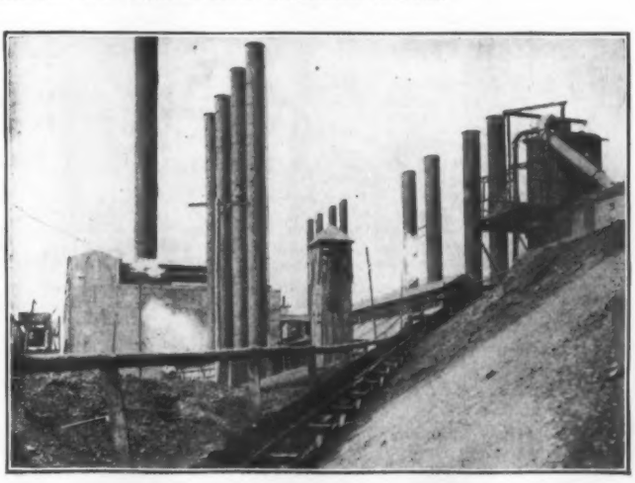


FIG. 10. SCRAPER CONVEYOR DISCHARGING TO OLD BOILER HOUSE

FUEL

Culm banks are common in the anthracite region, as up to a few years ago there was no demand for the finer grades of anthracite. Today the coal contained in these

The casual observer would hardly believe that this grade of fuel could be burned to advantage. That it can be utilized in a boiler furnace with good results is shown

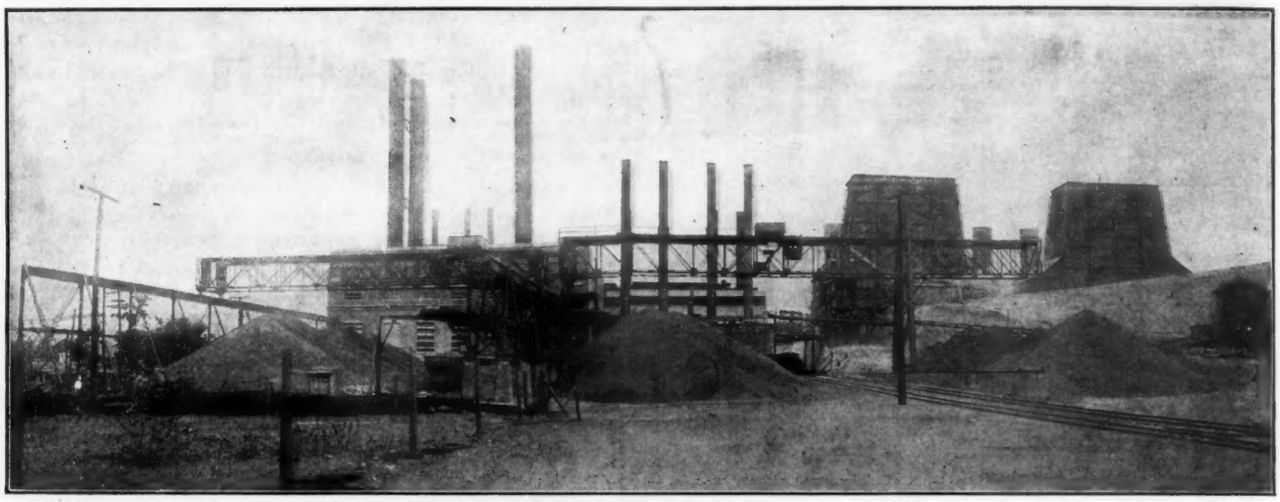


FIG. 11. GENERAL VIEW OF THE PLANT, SHOWING COAL-CONVEYING APPARATUS AND WATER-COOLING TOWERS

by a test run on four 480-hp. boilers in the old boiler room. The grate surface per boiler is 168 sq.ft., with 12.5 per cent. of air space. An air pressure of 1.72 in. of water was carried in the ashpit, with a draft over the fire of 0.02 in. and a draft under the damper of 0.45 in. of water. The boiler horsepower developed was 163 per cent. of the boiler rating, with an equivalent weight of water evaporated from and at 212 deg. F. of 6.07 lb. per pound of fuel.

Fuel is carried from the culm bank at the rear of the plant by a 6-in. reinforced chain with scraper every 2 ft. The conveyors, which travel at a speed of about 65 ft. per min., are shown in Figs. 8 and 10. The culm is taken to a crusher house shown at the left in Fig. 9, and as it contains considerable rock, it is taken to the top of the building and dumped into a ¾-in.-mesh revolving screen. The material passing through goes to the conveyor line, Fig. 10, which discharges to the boiler house where it is hand-fired to the furnaces. What does not pass through the screen goes to a pair of 24x24-in. chestnut rolls, and then drops into a second set of rolls of the same size, which reduces it to pea-coal size. It is then returned to the elevator and passed through the screen in order to mix it with the finer fuel coming from the culm pile. An electric jib crane with a 2-ton clamshell bucket is used for handling the culm from the pile to the conveyors.

Fuel for the new boiler room is obtained by rail from another culm pile owned by the company, and is stored in the yard close to the boiler house. Here it is handled by a 10-ton, three-motor traveling crane equipped with a two-ton grab bucket, Fig. 11. This takes the coal from either the cars or the bins and discharges it into a crusher, which passes it to a 30-in. belt conveyor, Fig. 12. The latter de-

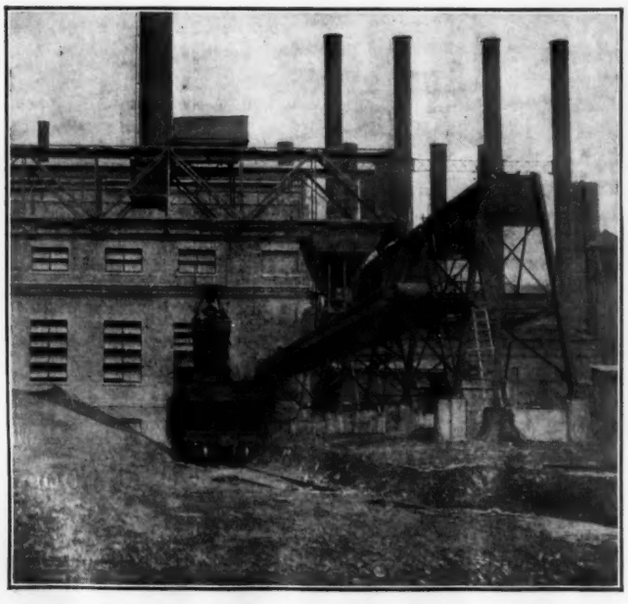


FIG. 12. ASH- AND COAL-HANDLING APPARATUS

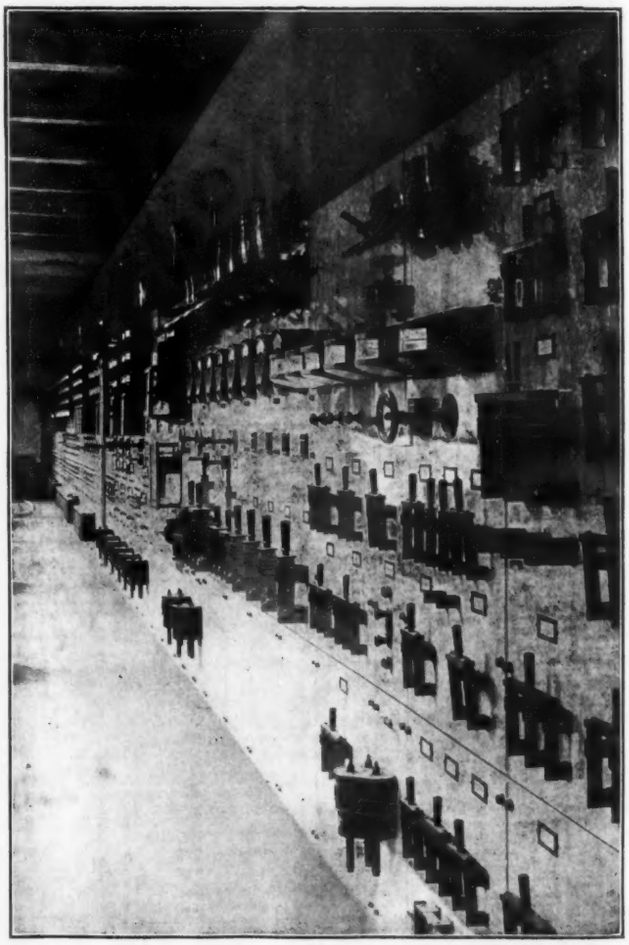


FIG. 13. STATION SWITCHBOARD

posits the coal onto a 32x32-in. overlapping bucket conveyor, which elevates it to the top of the building and dumps it into either one of three 24-in. belt conveyors that discharge into the bunkers. These conveyors have a capacity of about 120 tons of coal per hour and are equipped with automatic self-reversing traveling trippers arranged so that their travel may be controlled by hand.

Steam Heating

The exhaust-steam system of the company is one of the largest in the United States. It comprises over 15 miles of mains ranging from 2½ to 22 in. in size. Both the illuminating and suburban plant supply steam to the system, and it has been found advisable to carry the heaviest back pressure on the illuminating plant, which is nearest the center of distribution. With a winter temperature of 25 deg. F., the pressure at the suburban plant is carried at twice that at the illuminating plant. With lower atmospheric temperatures down to 10 deg., the pressure gradually changes until the suburban plant has three times that of the other, and below 10 degrees the difference in back pressure is four times greater than that at the illuminating plant.

One pound pressure is carried at the point of delivery to a building. If the pressure drops below this the engineer is at once notified. With the beginning of the heating season, the exhaust steam from one cylinder of the twin engine at the illuminating plant is turned into the heating main; exhaust steam from the compound engine at the suburban plant is turned into the main, but the back pressure on the low-pressure cylinder is not increased above 15 lb. In case it is necessary to carry more than 15-lb. pressure, owing to a drop in atmospheric temperature, the twin engine is used instead of the compound. If it is necessary to carry more than 15 lb. at all times, the piston of the low-pressure cylinder is removed, the valves are placed in the open position, and the piston-rod hole plugged. This allows any desired pressure to be carried. An auxiliary supply of live steam can be had, if for any

PRINCIPAL EQUIPMENT OF THE WASHINGTON AVENUE POWER PLANT, SCRANTON, PENN.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-generator	Horizontal, 12-stage	4500-kv.-a	Main unit	150 lb. steam, 1200 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
2	Turbo-generators	Horizontal, 8-stage	10,000-kv.-a	Main units	150 lb. steam, 1800 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
1	Engine	Cross-compound	36&66x48-in., 3500-hp	Main unit	150 lb. steam, condensing or non-condensing, 100 r.p.m.	Robert Wetherill & Co.
1	Engine	Twin, Corliss	36&36x48-in., 3500-hp	Main unit	150 lb. steam, non-condensing, 100 r.p.m.	Robert Wetherill & Co.
2	Generators	Alternating-current	2000-kv.-a	Main units	100 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
1	Turbo-generator	Horizontal—d.-c.	150-kw.	Exciter for main units	150 lb. steam, 3775 r.p.m., 125 volts	General Electric Co.
1	Motor-generator	A.-c. and d.-c.	225-hp. motor, 150-kw. gen.	Exciter for main units	3-phase, 60-cycle, 4000 volts, d.-c. 125 volts, 720 r.p.m.	General Electric Co.
1	Condenser	Surface	6000 sq.ft. cooling surface	With compound engine	26-in. vacuum	Alberger Pump & Condenser Co.
1	Condenser	Surface	11,000 sq.ft. cooling surface	With 4500-kv.-a. turbine	Within 2 in. of barometer, 70-deg. injection water	Alberger Pump & Condenser Co.
1	Condenser	Surface	20,000 sq.ft. cooling surface	With 10,000-kv.-a. turbine	Within 2 in. of barometer, 70-deg. injection water	Alberger Pump & Condenser Co.
1	Condenser	Surface	30,000 sq.ft. cooling surface	With 10,000-kw. turbine	29+-in. vacuum	Wheeler Condenser & Engineering Co.
1	Pump	Volute	20-in	With 4500-kv.-a. turbine condenser	Turbine-driven, triplex	Alberger Pump & Condenser Co.
1	Pump	Volute	28-in	With 10,000 kv.-a. turbine condenser	Turbine-driven, triplex	Alberger Pump & Condenser Co.
1	Pump	Volute	10-in	With cross-compound engine	Turbine-driven	Alberger Pump & Condenser Co.
1	Turbine	Single-stage		Driving 20-in. pump	150 lb. steam	Alberger Pump & Condenser Co.
1	Turbine	Single-stage		Driving 28-in. pump	150 lb. steam	Alberger Pump & Condenser Co.
1	Turbine	Single-stage		Driving 10-in. pump	150 lb. steam	Alberger Pump & Condenser Co.
1	Turbine	Single-stage		Driving turbo and cen. pump	150 lb. steam, 1500 r.p.m.	General Electric Co.
1	Pump	Steam-driven air	8x20x12-in	With compound-engine condenser	150 lb. steam	Alberger Pump & Condenser Co.
1	Pump	Steam-driven air	8x20x12-in	With 4000-kw. turbine condenser	150 lb. steam	Alberger Pump & Condenser Co.
1	Pump	Steam-driven air	12x30x16-in	With 7500-kw. turbine condenser	150 lb. steam	Alberger Pump & Condenser Co.
1	Pump	Turbo	No. 70	With 10,000-kw. turbine condenser	Turbine driven, 1500 r.p.m.	Wheeler Condenser & Engineering Co.
1	Pump	Centrifugal	20-in	With 10,000-kw. turbine condenser	Turbine driven, 1500 r.p.m.	Wheeler Condenser & Engineering Co.
6	Towers	Cooling	24x70-ft. each	Cooling condensing water	Fan and natural draft	Alberger Pump & Condenser Co.
2	Towers	Cooling	250 ft. long, 90 ft. high	Cooling condensing water	Natural draft	Wheeler Condenser & Engineering Co.
2	Pumps	Duplex, outside-packed	16x10x18-in	Boiler-feed	150 lb. steam, automatic control	Scranton Pump Co.
2	Governors	Kitts		On boiler-feed pumps		Kitts Mfg. Co.
2	Heaters	Stilwell, open		Heating boiler-feed water	Using exhaust steam	Platt Iron Works Co
2	Motor-generators	Synchronous motors, d.-c. gen.	1400-hp.—1000-kw.	Railway service	550 volts, 514 r.p.m.	General Electric Co.
2-3	Motor-generators	Synchronous motors, d.-c. arc gen.	250-hp	Arc-light service	4000 volts, 6.6 amp., d.-c., 514 r.p.m.	General Electric Co.
1-2	Motors and generators	Synchronous motor, d.-c. arc gen.	186-hp	Arc-light service	4000 volts, 6.6 amp., d.-c., 514 r.p.m.	General Electric Co.
1	Motor-generator	Induction motor, d.-c. gen.	150-hp. motor, 100-kw. gen.	Motor service	250 volts, d.-c., 580 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Motor-generator	Induction motor, d.-c. gen.	300-hp. motor, 200-kw. gen.	Motor service	250 volts, d.-c., 580 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Engine	Marine	10x18x10-in	Drives 125-volt generator	150 lb. steam, 340 r.p.m.	General Electric Co.
1	Generator	Direct-current	100-kw	Exciter unit	125 volts, 340 r.p.m.	General Electric Co.
4	Boilers	Water-tube, Sterling	480-hp	Steam generators	150 lb. steam, Dutch-oven furnaces	Babcock & Wilcox Co.
4	Boilers	Water-tube	600-hp	Steam generators	150 lb. steam, Dutch-oven furnaces	Edge Moor Iron Co.
5	Boilers	Water-tube	300-hp	Steam generators	150 lb. steam, hand-fired	Heine Safety Boiler Co.
6	Boilers	Water-tube, double-deck	558-hp	Steam generators	150 lb. steam, will be stoker-fired	Babcock & Wilcox Co.
2	Blower sets	Engine-driven	14-ft. dia	Forced-draft	Variable-speed	American Blower Co.
1	Blower set	Engine-driven	10-ft. dia	Forced-draft	Variable-speed	American Blower Co.
1	Blower	Motor-driven	5-ft. dia	Ash-removal system	Intermittent	American Blower Co.
1	Motor	Alternating-current	100-hp	Driving 5-ft. ash blower	Intermittent	General Electric Co.
1	Crane	Jib	2-ton	Handles culm	Motor-operated	Brown Hoisting Machinery Co.
1	Conveyor	Belt	30 in. wide	Handles coal from cars to belt conveyor	Intermittent, motor-driven	Robins Conveyor Belt Co.
1	Conveyor	Bucket	32x32-in	Handles coal from 30-in. to 24-in. conveyor	Intermittent, motor-driven	Mead-Morrison Mfg. Co.
3	Conveyors	Belt	24-in wide	Handles coal to bins	Intermittent, motor-driven	Robins Conveyor Belt Co.

cause the exhaust-steam supply should be insufficient, by reducing the live-steam pressure from 150 to 5 lb. With 40-lb. back pressure about 130,000 lb. of steam is furnished to the system per hour by the suburban plant, and about 50,000 lb. by the illuminating plant at 10-lb. back pressure.

Fig. 13 is a view of the suburban-station switchboard, and Fig. 14 the busbar compartments. The two plants and the substations are connected by tie lines, of which there are four between the two power stations, four from the suburban plant to the Dix Court substation, and one from the latter to the illuminating plant. This arrangement, in connection with the motor-generator sets, makes

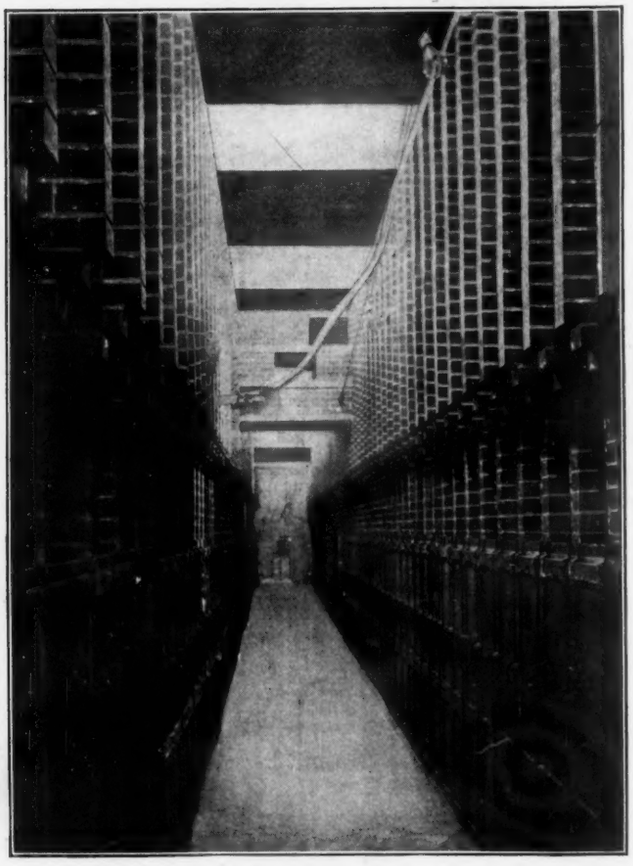


FIG. 14. BUSBAR COMPARTMENTS

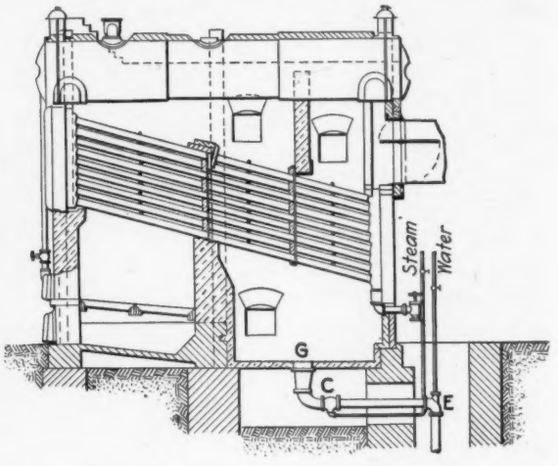
a flexible combination, because in case of an interruption in service the motor-generator sets can be used to generate either alternating or direct current.

There are also two tie lines from the Dix Court substation to the Hampton power plant of the Delaware, Lackawanna & Western R.R. Co., which provide a breakdown arrangement to the advantage of both companies. The conditions are that the Hampton plant has a heavy day load and the illuminating company a heavy night load, and either is supposed to help the other to the extent of 2500-kw. per hr., or more if desired when it is possible to do so.

In building the new power house the principal problems encountered were those of keeping the service up to the standard and at the same time tearing down the old building and constructing the new one over the old. Foundations for new units were built and old ones dismantled, requiring planning weeks in advance. The remodeling was carried on with but one complete shutdown, and that for only about 15 minutes, which reflects great credit upon the engineer in charge. The work cost not far from $2,000,000.

Schutte & Koerting Soot Conveyor

When the soot from the tubes of a boiler is blown down, most of it collects in the dust-settling chamber, from which it is occasionally removed through the clean-out doors. This operation necessarily involves labor and time out of service for the boiler. The illustration shows the application of a conveyor to a boiler setting for removing the soot each time the tubes are cleaned. It is operated by steam pressure and is installed in a pipe line that has connections to the combustion chamber of the



STEAM-OPERATED SOOT CONVEYOR

various boilers, as at *C*. Each connection is furnished with a slide gate, as at *G*, to cut in or out any particular boiler. Only the slide gate to the boiler being cleaned is open. Steam is then admitted to the conveyor, creating a high vacuum, and floating particles of soot are drawn into the system.

Sometimes the amount of soot to be handled is considerable, and as the steam consumption of the conveyor is the same under all conditions, after leaving the conveyor it makes a mixture not readily discharged, and for this reason a special elbow *E* is used. The boss is tapped to take a centrifugal spray nozzle, which injects water to wash the soot down the discharge pipes.

As the water is under pressure and as the nozzle is connected to the discharge in the direction of the flow, it not only helps to wash out the soot, but the water issuing from the centrifugal nozzles gives added velocity sufficient to overcome any reasonable counter pressure.

This soot conveyor is manufactured by the Schütte & Koerting Co., Thompson and Twelfth St., Philadelphia, Penn.

Painting Boiler Drums—In a plant equipped with B. & W. boilers developing 8400 hp., the interiors of the drums were scalded, painted both above and below the water line with silica-graphite paint, and allowed 48 hr. to thoroughly dry. This treatment was repeated every ten months. Pitting stopped, and where it had previously taken six men seven days to clean the drums of one boiler, two men now clean them in a day. This experience is quoted from a letter of the chief engineer of the New York Life Insurance Co., in the April issue of "Graphite."

The Southwark-Harris Diesel Engine

SYNOPSIS—A two-stroke-cycle engine with no scavenging or starting valves in the head, employing a stepped piston for both starting and scavenging and possessing unusual means of fuel control.

The impetus given the heavy-oil-engine industry in this country by the expiration of the original Diesel patents in 1912 has been marked particularly by the number of steam-engine builders who have entered this field. Some, choosing to follow foreign practice, are building under license from foreign firms with modifications to suit local conditions; others have developed what may be termed distinctly American designs. Among the latter may be mentioned the Southwark-Harris Diesel engine, built by the Southwark Foundry & Machine Co., of Philadelphia, from the designs of Leonard B. Harris.

This is a two-stroke-cycle type intended primarily for marine service, but also adapted to stationary work, the engine being somewhat simpler for the latter service, as no reversing is required. Because of the ingenious, yet simple and flexible, control for maneuvering, the marine type will be described.

Unlike most two-stroke-cycle Diesel engines, there are no starting nor scavenging valves in the head, the only opening being for the fuel atomizers, of which there is one to each cylinder in both marine and stationary types. There are two atomizer-actuating levers in the marine type, one for ahead and the other for astern; in the stationary type there is, of course, only one atomizer-actuating lever. This arrangement makes possible a very simple cylinder-head casting.

The pistons, as shown in Fig. 3, are stepped, the lower part serving as a scavenging pump besides acting as a guide in the place of a crosshead. The cylinders are in pairs and each scavenging piston serves the adjacent cylinder of that pair through the passage A, valve V_2, manifold M and port D. This will be understood when it is

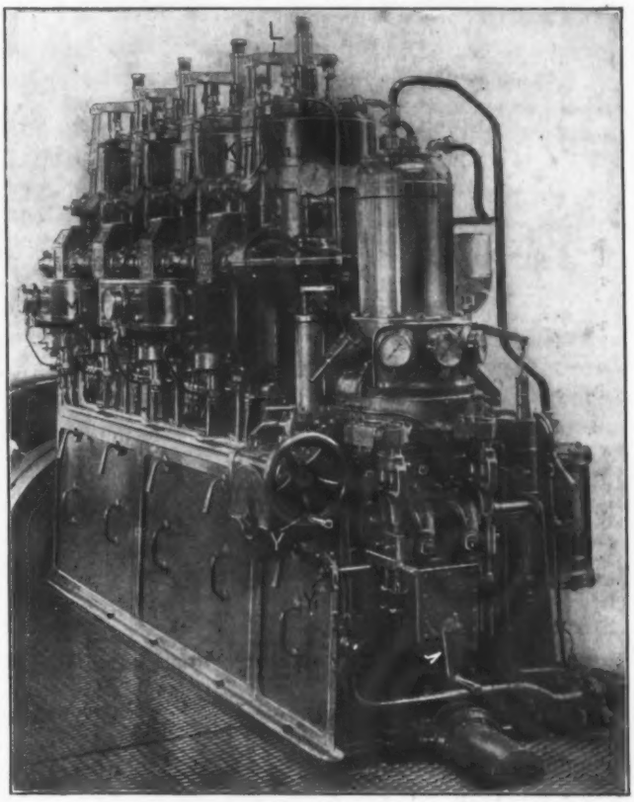


FIG. 2. END VIEW SHOWING PUMPS

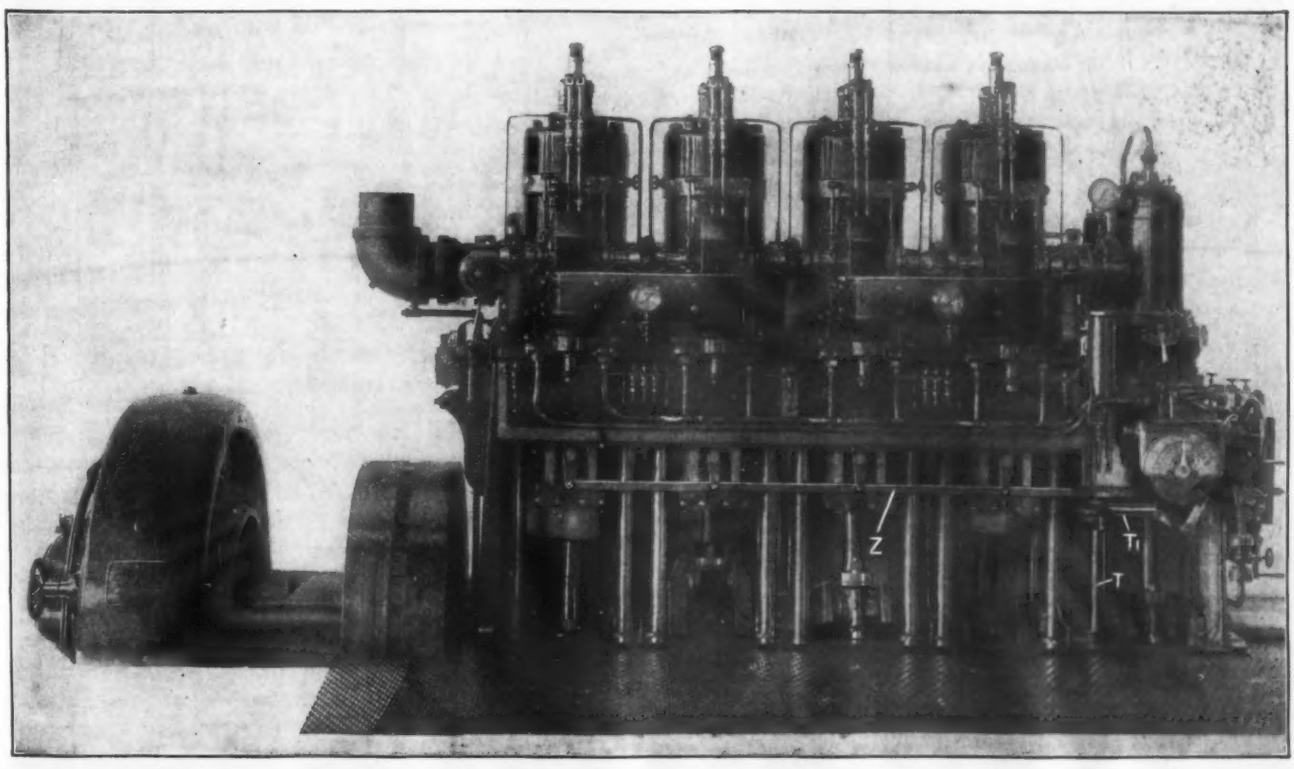


FIG. 1. 240-HP. SOUTHWARK-HARRIS DIESEL ENGINE

remembered that the cranks of a pair are set at 180 deg. Therefore, when the scavenging piston of cylinder No. 1 is traveling upward, compressing the air in the scavenging cylinder, ports and manifold, the pistons of No. 2 are traveling downward, and when No. 2 working piston has uncovered its port *D*, the scavenging air, under a pressure of about 7 lb., will rush in and force the spent products of combustion out through the exhaust ports *E*. The air-delivery valve of cylinder No. 2 prevents the scavenging air of No. 1 from being forced into the scavenging

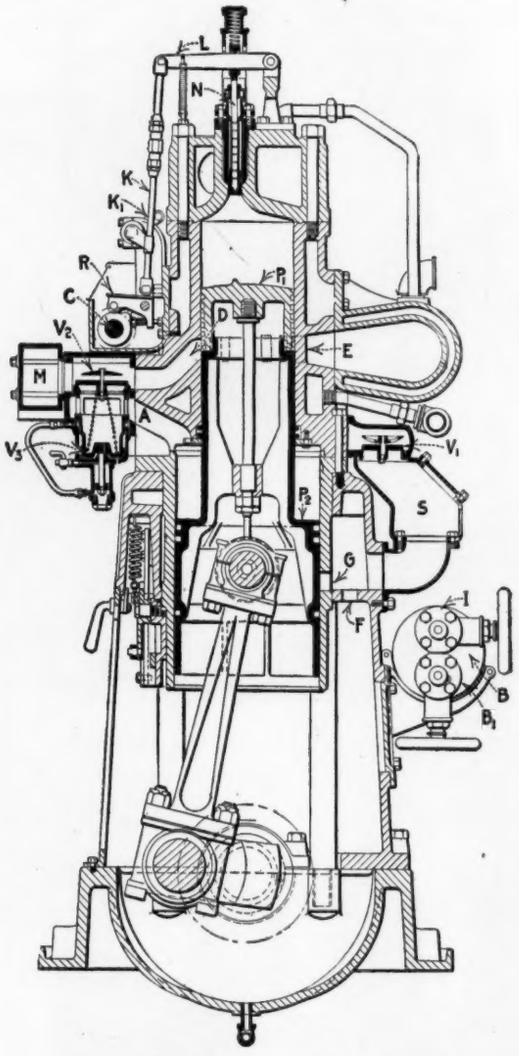


FIG. 3. SECTIONAL ELEVATION

P_1 is the main piston; P_2, the scavenging and air-starting piston; V_1, scavenging-air inlet valve; A, scavenging-air outlet passage and starting-air inlet passage; V_2, scavenging-air delivery valve; M, manifold; D, scavenging-air inlet ports; V_3, the air-operated intercepting valve; O, outlet for starting air; S, silencer; F, vents; B, injection-air storage bottle; C, camshaft; R, atomizer-actuating rockers; K, push rods; L, atomizer levers; N, atomizer spindle; E, exhaust ports; I, injection air from compressor; B, bypass to starting bottles; K_1, bell crank.

cylinder of No. 2 while its pistons are on the down stroke.

An unusual feature of this stepped piston is its use for starting the engine—a most important factor in marine work, as it avoids admitting cold starting air to the highly heated working cylinders and pistons when reversing and maneuvering. Moreover, as the area of the stepped piston is greater than that of the working piston, starting air of relatively low pressure, 175 lb., can be employed. Since the starting is independent of the working cylinders, the fuel can be admitted to the latter while the starting air is still on. This will be found advantageous when starting under load, as the starting air can thus be used to help out until the momentum has been built up.

Of interest in this connection are the diagrams of Fig. 4. No. 1 is from the scavenging cylinder when starting

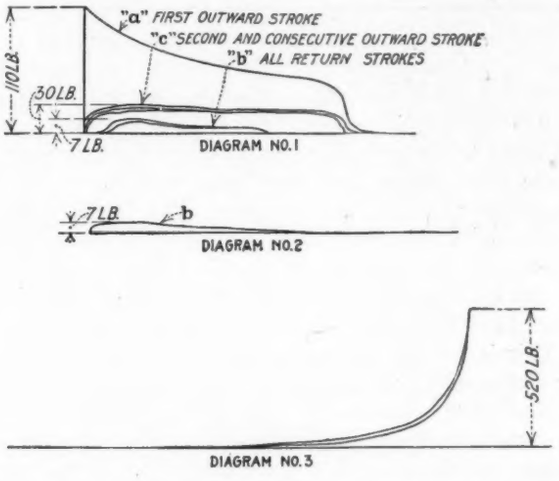


FIG. 4. INDICATOR DIAGRAMS FROM WORKING AND STARTING CYLINDERS

with air, while No. 3 was taken simultaneously in the working cylinder. Line *a*, diagram No. 1, represents the first outward stroke, *b* the return stroke, and *c* the successive outward strokes until the starting air is shut off. It will be noted that after the first stroke, a pressure of only 30 lb. is required, owing to the power given back in the working cylinder by the expansion of the compressed

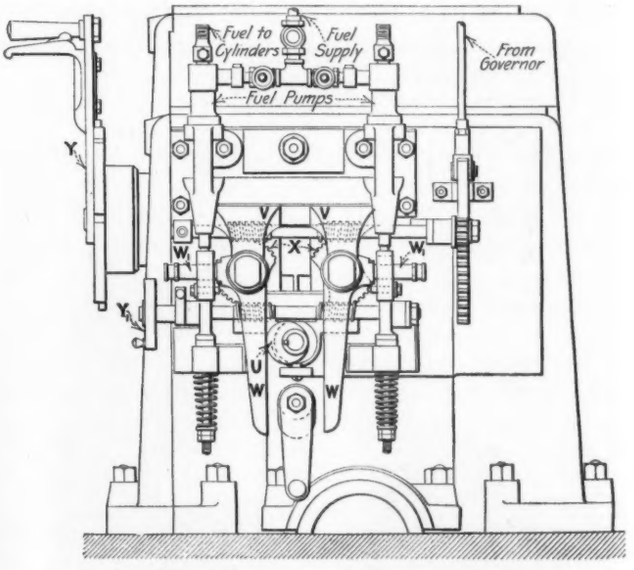


FIG. 5. SHOWING FUEL CONTROL

air within it. Diagram No. 2 shows the normal working of the scavenging piston.

Starting and fuel-injection air is furnished by a two-stage compressor driven off the main shaft and having a control valve on the suction. The compressor delivers the high-pressure air for fuel injection directly to a steel air bottle mounted at the back of the engine frame. The

starting air is supplied to the starting bottles through a reducing valve.

There is a separate fuel pump for each cylinder, making four in all in the engine shown. These are mounted at the end of the engine (see Fig. 2) and the stroke is varied by the governor.

A better idea of the operation of the fuel pumps will be gained by reference to Fig. 5. First, however, it will be necessary to revert to Fig. 1, which shows the pump shaft T_1 driven from the main crankshaft through the vertical shaft T and worm gears. At the end of T_1 is mounted a cam U, Fig. 5, which acts laterally upon the bell-crank levers W; these in turn work the pumps through the arms W_1, working in yokes on the pump stems. The fulcrum pins of the bell cranks are carried on laterally sliding plates V, the movement of which is effected

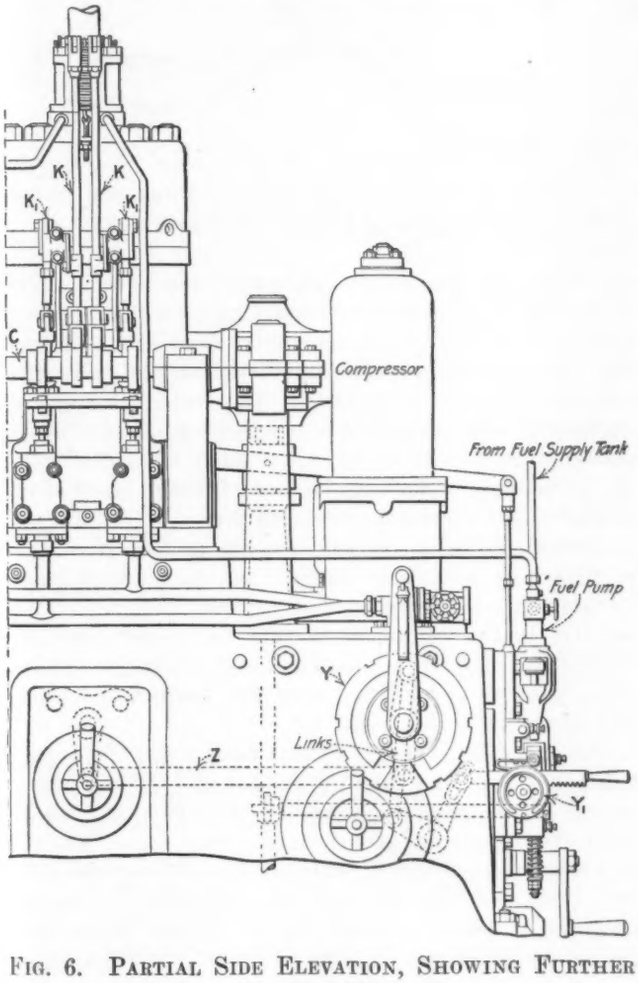


FIG. 6. PARTIAL SIDE ELEVATION, SHOWING FURTHER THE CONTROL FEATURES

through two worm spindles, each carrying a pair of right-and-left-hand worms meshing with sectors X. The upper worm spindle extends to the right and connects through gearing with the governor shaft, while the lower worm spindle extends to the left carrying the handwheel Y_1 and connecting through links and a rack (see Fig. 6) with the main control handle Y.

When the pointer of the main control handle is in the central, or "stop," position (see Fig. 1) the bell-crank levers W (Fig. 5) are separated so as not to be actuated by the cam U. Through the arrangement of links shown in Fig. 6, this position of the bell cranks is held ordinarily through the starting period. When the control handle is turned past the first notch to the running position, the lower worm spindle is rotated and, by means of the sectors and slides, brings the bell-crank levers closer together, so that they are actuated by the cam U, and the fuel pumps are set in operation. The governor, now acting through the upper worm spindle, is able to control the position of the bell cranks and vary the stroke of the pumps to suit the load. The small handwheel Y_1 permits manual control of the fuel without altering the position of the main control wheel Y. By this means the engineer is enabled to control the speed of the engine at will, and the governor will maintain control at this speed. This feature is especially useful in marine work when running through a heavy head sea with the engine racing.

In addition to the fuel control through varying the stroke of the pumps, the lift of the fuel atomizers may be altered at will from the control wheel while the engine is running. Referring to Fig. 3, the lower ends of the atomizer push-rods may be swung outward through the arc on the upper side of the rockers, which in turn are actuated by the cams on the main camshaft. It will be seen that when the push-rods are at the extreme right the rockers can be actuated without imparting any motion to the atomizer spindles. When they are moved to the extreme left the atomizers will have their greatest travel. Intermediate positions of the push-rods on the rockers will correspond with definite openings of the atomizers. These push-rods are shifted by means of the bell cranks shown, which in turn are operated through vertical rods connected with the horizontal bar Z (Figs. 1 and 6), also connected with the control handle. The operation is obvious.

A four-cylinder, 240-i.hp. Southwark-Harris engine has just been installed in the yacht "Southwark," owned by C. P. Vauclain, of Philadelphia. The "Southwark" is 98 ft. overall, 16-ft. beam and 7-ft. draft, and on her first trial trip made a speed of about 10 miles per hour against the tide and a head wind, with the engine turning up at 225 r.p.m. Extensive tests are now being made and the results will be available at an early date.

The principal dimensions, horsepower, weight, etc., of the sizes listed are given in the following table:

PARTICULARS OF STATIONARY TYPE

I.Hp.	No. of Cylinders	I.Hp. per Cylinder	Cylinder Diameter, In.	Stroke, In.	R.p.m.	Approximate Weight Without Flywheel, Lb.	Weight per I.Hp., Lb.	Floor Space, Sq.Ft.	Length Overall, Ft. In.
120	2	60	9	13	300	14,000	117	21.6	6 9
240	4	60	9	13	300	25,000	104	34	10 2
360	6	60	9	13	300	35,000	97	45	13 7
225	2	112.5	12	21	200	27,000	120	51	9 8
450	4	112.5	12	21	200	47,000	104	80	15 4
675	6	112.2	12	21	200	66,000	102	110	21
400	2	200	16	28	150	.....	...	116	14 6
800	4	200	16	28	150	.....	...	180	22 6
1200	6	200	16	28	150	.....	...	244	30 6
				MARINE TYPE					
240	4	60	9	13	300	25,000	104	34	10 2
360	6	60	9	13	300	35,000	97	45	13 7
480	8	60	9	13	300	44,000	91.5	56.5	17
450	4	112.5	12	21	200	47,000	104	80	15 4
675	6	112.5	12	21	200	66,000	102	110	21
900	8	112.5	12	21	200	85,000	94.5	140	26 8
800	4	200	16	28	150	.....	...	180	22 6
1200	6	200	16	28	150	.....	...	244	30 6
1600	8	200	16	28	150	.....	...	308	38 6

Increased the Capacity of the Plant—B. M. Babcock informs us that in his letter under the foregoing caption, May 18 issue, the beginning of last paragraph on page 685 should read: "The grate surface was extended from 6 ft. in length to 8 ft., giving 56 instead of 42 sq.ft. of grate surface," instead of, "the grate surface was extended from 42 in. in length to 56 in."

Priming a Centrifugal Pump*

By E. M. Ivens

SYNOPSIS—Several letters on the troubles experienced in priming centrifugal pumps have appeared recently in Power. *Interested, and drawing on his wealth of experience in this practice, Mr. Ivens presents the following, which shows several ways of overcoming priming troubles. It is a timely, practical and interesting article.*

The several letters that have appeared in Power on the subject of priming centrifugal pumps indicate that much interest centers in that topic.

It is more or less well known that before a centrifugal pump of the suction type can pick up its water, the air contained in the space between the top of the impeller blade or blades and the surface of the water in the suction basin must be expelled. With the removal of this air there occurs, inside and outside of the pump and piping, a difference of hydrostatic pressure which causes the water to rise in the suction pipe and submerge the rotating parts, and immediately, discharge of water begins. The height to which water may be so lifted obviously depends upon the barometric conditions at the time. At sea level the theoretical lift is equivalent to 14.7 lb. of pressure (approximately 34 ft.), but owing to the impracticability of obtaining and maintaining a perfect vacuum, it is impossible to operate a pump having so high a lift. Pump manufacturers seem to have agreed that 25 ft. (dynamic) is the practical limit and advise that less than this be employed if possible.

There are but two principles that may be followed in priming a centrifugal pump and its piping. One is to actually withdraw the air, using vacuum-forming apparatus of some kind, and the other is to displace the air with the liquid to be pumped. Fig. 1 illustrates an elementary installation wherein the former method of priming is employed, and Fig. 2, the latter.

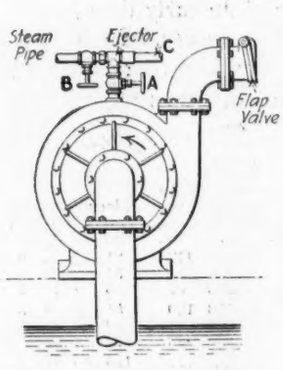


Fig. 1. Steam Ejector for Priming Pump

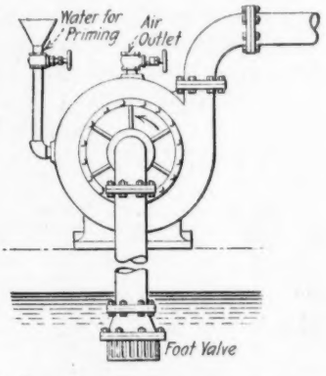


Fig. 2. Displacing Air by Filling Pump with Water

In Fig. 1 the air is exhausted by means of the well-known steam ejector placed on top of the pump casing. As shown, the system is closed to the atmosphere by means of the flap valve placed at the end of the discharge pipe. Plainly, this method can be employed only when steam is available, and even then it is objectionable in that the flap valve is with difficulty made air-tight. The method is exceptionally tedious and expensive when relatively high lifts and long suction and discharge pipes are necessary.

In Fig. 2 water is admitted from some outside source, usually an overhead tank provided for the purpose, through the funnel shown and is held by means of the foot-valve attached to the lower end of the suction pipe. An air vent is provided at the top of the volute to prevent "locking." It frequently happens that obstructions find their way through the strainer and lodge on the seat, preventing a complete closure of the valve and making priming temporarily impossible. Expensive shutdowns often occur and considerable annoyance is experienced with foot-valves, when water is drawn from rivers, lakes or other open bodies of water, as is done in rice irrigation and land reclamation.

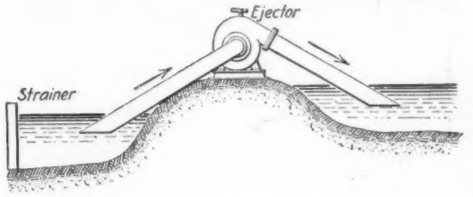


Fig. 3. Typical Location of Pump for Drainage or Irrigation Systems

Centrifugal-pump installations are seldom as simple as those just described. More often, long and angular suction lines are necessary and various other conditions peculiar to the requirements have to be met, such as method of drive, angle of suction and discharge nozzles, stability of water level in the suction basin and the nature of the pumping head.

The writer is fortunate in that he has had the opportunity to design and install a number of pumping plants having a wide range of capacities and pumping heads. With the experience gained it has been found possible to overcome the typical priming difficulties previously mentioned and thus preclude the possibility of annoyance due to loss of vacuum, and at the same time meet the conditions imposed by the nature of the duty. Following are three descriptions of priming methods that have given satisfaction and may be applied to advantage in many places. These will be recognized as embodying the principles already given, but somewhat modified to meet the requirements of each installation.

Fig. 3 illustrates an installation of a low-lift, large-capacity pump such as used in drainage projects. As may be noted, both suction and discharge ends are water-sealed and consequently the use of the troublesome foot and flap valves is dispensed with. A steam ejector is fitted to the top of the pump casing for priming. In the event that steam is not available, a vacuum pump, independently operated, may be substituted. This method of installation possesses other advantages not pertinent here.

*"Power," Mar. 2, p. 294; Apr. 6, p. 481; Apr. 20, p. 550; May 4, p. 615; June 8, p. 778.

Fig. 4 shows a row of motor-driven turbine pumps installed in the water-works plant of a small Louisiana town. The four larger pumps have each a capacity of 250 gal. of water per min. against 100 lb. pressure and are reserved for fire purposes only. The smaller pump is for constant service and has a capacity of 100 gal. per min. against 45-lb. pressure. Current for the motors is supplied by two oil-engine-driven alternators.

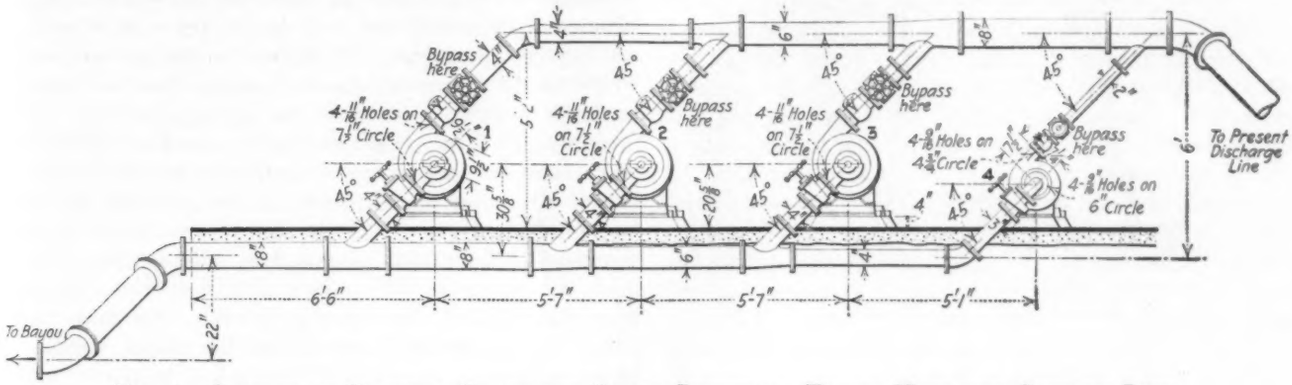


FIG. 4. LAYOUT OF PUMPING PLANT FOR SMALL LOUISIANA TOWN; NOTE THE SUCTION LIFT

The arrangement of valves and piping is such that any one or all pumps may be placed in service at any time. The suction line is 8 in. diameter, 125 ft. long, and the static suction lift is 12 ft.

These pumps are primed by the method of displacement. Located in the suction line and in the manner shown in Fig. 5, is a surface priming valve designed by the writer. This valve is a combination check and flap valve having all parts made readily accessible by suitably located hand holes. Fig. 6 shows the exterior of the valve and Fig. 7 a vertical cross-sectional view.

The operation of priming and the action of the valve are as follows: Water is admitted from the standpipe to the pumps through the bypasses indicated in Fig. 4, and the air is vented off through pet-cocks provided on the tops of the pump casings. When water appears at the pet-cocks, the system is filled from the discharge nozzles to the surface valve. Between the valve seat and the water surface there remains an unfilled space or air pocket. Before the column can be started this air must be disposed of, and this is done by the action of the small check valve shown at *A*, Fig. 7, and in the manner later explained.

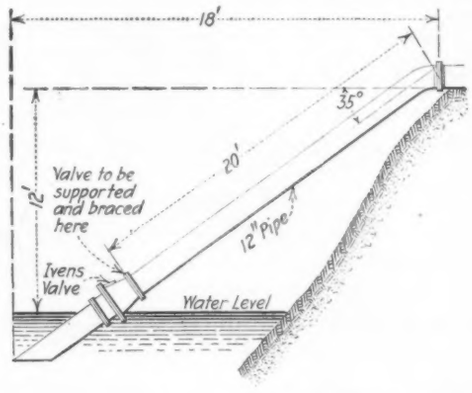


FIG. 5. APPLICATION OF VALVE SHOWN IN FIG. 7

The motor is now started, and when the full-load speed is reached there appears a tendency to force the contained water out of the discharge, and a surging results. This relieves the pressure above the small check valve, it is opened by the air pressure beneath and air rushes in from the pocket, breaking the partial vacuum created. The column pressure then closes the check valve, and the air admitted by its raising seeks the high point, which is the discharge nozzle of the pump. Continued operation of the motor is accompanied by continued making and breaking of vacuum due to surging, until finally the air pocket disappears. The large flap is then opened by the rising column and occupies the recess provided in the valve body. A free passage is offered to the column, and the only resistance encountered is that caused by part of the weight of the flap.

As shown in Fig. 7, cleaning of the valve seat may be easily accomplished through the handholes and a thorough examination or renewal of all moving parts made by removing the large cover plate to which the flap is attached.

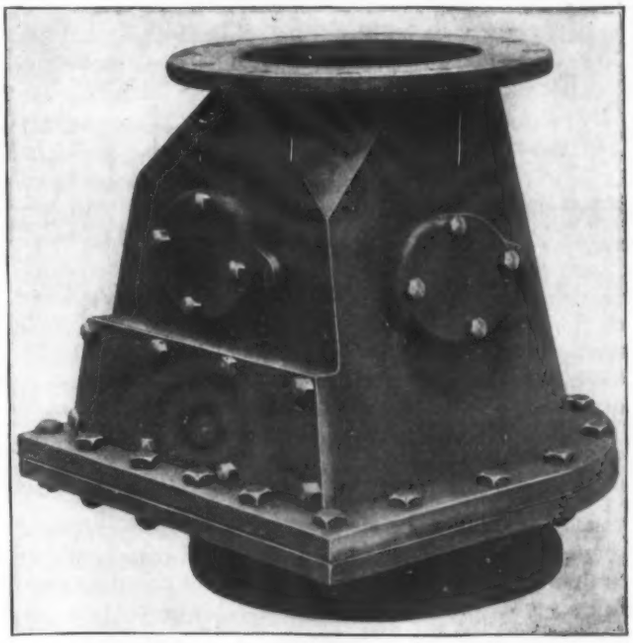


FIG. 6. THE IVENS PRIMING VALVE

The writer has used this valve with gratifying results on medium-lift pumps where it was necessary (owing to fluctuating suction lift) to attach the valve direct to the suction elbow, or Y connection, on the pump

and some 20 ft. above the water level. Several rice-irrigation plants located on the Mississippi River are using the valve in this way.

A rather interesting system of automatic priming suggested by the writer is employed by a large sawmill in Louisiana. A diagrammatic illustration of the installation is shown in Fig. 8. The equipment consists of a 750-gal., two-stage turbine pump, direct-connected to a 100-hp., 2200-volt, three-phase, 60-cycle, 1740-r.p.m. motor, and a 6x4½-in. vacuum pump, gear-driven by a 5-hp., 220-volt, three-phase, 60-cycle motor. The plant is located on the Mississippi River about a mile and a half from the electric generator which furnishes the current for the motors.

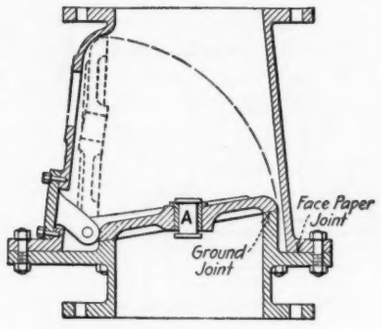


FIG. 7. SECTION OF IVENS PRIMING VALVE

The suction of the vacuum pump is connected to a chamber and thence to the discharge nozzle of the pump, as shown. The chamber is made of 6-in. pipe and contains a cedar float suspended by a rod attached to a check valve above. The weight of the float and rod is sufficient to hold the check open under 25-in. vacuum when the chamber is empty. If, by any chance, water should enter the chamber, the buoyancy of the float permits the check to close immediately. This prevents water being drawn into the cylinder of the vacuum pump.

The motor operating the vacuum pump is equipped with a pressure-control switch, the pressure pipe of which is connected to the discharge nozzle of the centrifugal pump. Operation is as follows:

Both motors are started simultaneously and the vacuum pump rapidly withdraws the air, priming the system. When a pressure of 10 lb. is reached in the water-discharge piping, the pressure switch actuates and the vacuum pump is stopped. If, at any time, the pump should lose its column, the vacuum pump starts automatically and the process of priming is repeated.

This installation has no regular attendant, and difficulty has never been experienced since first starting.

It is quite true, as Mr. Palmer says (POWER, Apr. 6 issue), that considerable trouble has been experienced in priming centrifugal pumps, but often the operator is to blame and frequently the fault lies in the method of installing the equipment. In answer to trouble calls the writer on two occasions traveled several hundred miles, to find the pump rotating in the wrong direction. On a number of other occasions the trouble was caused by leaky suction pipes or air locking due to the accumulation of air at high points in the suction piping. One unpleasant experience was caused by the designer's disregard of frictional loses, and an attempt was being made to operate several pumps with a suction lift far in excess of that theoretically possible. In every instance the operator first stated that the pumps were defective and then, after his difficulty had been overcome for him, it was "priming trouble."

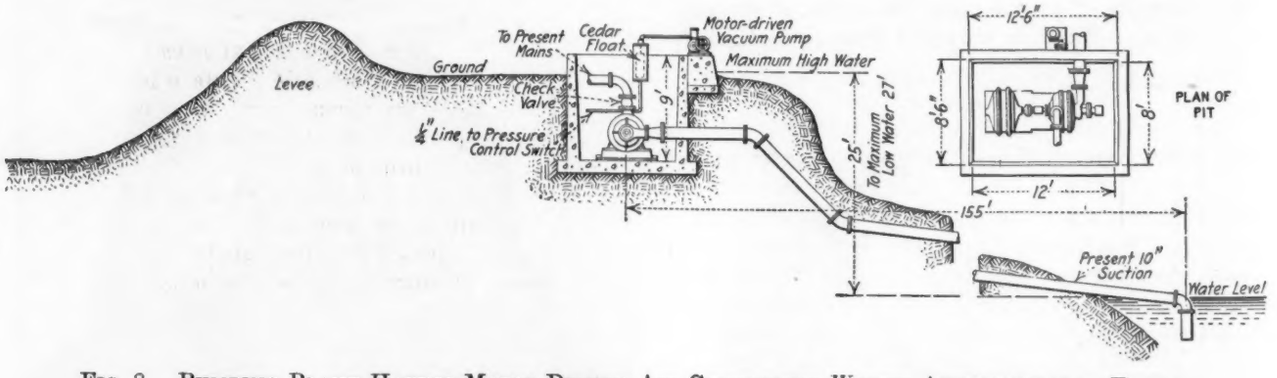


FIG. 8. PUMPING PLANT HAVING MOTOR-DRIVEN AIR COMPRESSOR WHICH AUTOMATICALLY KEEPS PUMP PRIMED

Characteristics of Radiation Pyrometers

The Bureau of Standards will have ready for distribution shortly a paper entitled "Characteristics of Radiation Pyrometers." A careful study of this type of temperature-measuring instrument was considered urgent on account of the extensive use of radiation pyrometers in the technical industries. These instruments are widely used in the temperature control of the various processes involved in iron and steel manufacture, alloy-foundry work, glass, ceramics, and brick manufacture, smelting, gas works, steam generation, lamp manufacture, etc.

Many of the instruments examined show different temperature readings for different focusing or sighting distances. Errors thus occasioned may amount to several hundred degrees. The effect of dirt upon the lenses and mirrors is of serious importance. The question as to whether the pyrometer absorbs all the heat radiation falling upon it is discussed, and the theory of the instrument and the connection of its behavior with the theoretical radiation laws are given.

The bureau receives a large number of these instruments for test and standardization from various technical industries throughout the country. Heretofore, this testing required about three days for a single instrument, on account of the difficulty in heating a furnace to an exactly uniform temperature. A new method has been developed which permits a satisfactory standardization of a radiation pyrometer within one hour. Many suggestions are given for minimizing the errors to which the pyrometer is subject, and it is shown that this type of instrument, suitably designed, adequately calibrated and correctly used, is a trustworthy pyrometer having many advantages over other types of temperature-measuring devices, both for scientific and technical use.

Firebrick for Boiler Settings*

By William A. Heisel†

SYNOPSIS—An unusually complete, interesting and highly valuable article on an important subject about which little has been written.

Chemically pure fireclay consists of silica and alumina and combined water. Pure fireclay is called "kaolinite" and consists of about 40 per cent. of alumina, 46 per cent. of silica and 14 per cent. of combined water. It acquires in its travels various impurities, such as iron, lime, magnesia, alkalies, soda and potash, together with more or less organic material.

In this country the most important fireclays are found in Kentucky, Pennsylvania and Missouri.

Physical and Chemical Properties of Fireclays

Flint clays are more nearly chemically pure than plastic clays, because of the difference in their formation. The flint clays have practically no plasticity, while the plastic clays vary from slightly to highly plastic.

The colors of plastic fireclays range between the two extremes of white and black, with such intermediate colors as gray, brown and olive. Flint clays do not show a marked color difference, being either white, gray or mottled black. The color of clay is not always a safe guide in its selection for quality, for in some cases it indicates the amount of contained impurities in both the flint and the plastic clays.

Impurities in Fireclays

The impurities in fireclays occur in various forms—the iron, for instance, as pyrites (sulphite of iron), sometimes in large particles widely distributed, and at other times in small particles uniformly distributed. Again, the iron occurs as carbonate of iron, usually in large, hard lumps. The lime occurs as gypsum and as limestone. When magnesia occurs, it is usually associated with lime in limestone. The alkalies enter in the form of mica or feldspar.

The amount of contained impurities in the finished product, firebrick, is not always a reliable indication of the temperature at which the brick will soften, as is clearly shown by the curves representing the result of 44 different tests.

Method of Manufacture

The impossibility, on account of excessive shrinkage and consequent liability to warpage, of using all raw clays makes necessary the calcining, or burning, of some of them, preferably the flint clay, to obtain a high-grade product. The amount to be used of this calcined, or burned, clay is determined by the physical and chemical qualities the manufacturer is striving to obtain for the character of work. As flint clays and calcined clays have no plasticity, a bonding material is necessary, this being supplied by a plastic clay. The amount of the latter used for bonding varies from 15 to 50 per cent. In some classes of work, practically all plastic clay is used.

*Paper before the Ohio Society of Mechanical, Electrical and Steam Engineers.

†With the Charles Taylor Sons Co., Cincinnati, Ohio.

Firebricks are used in innumerable ways—in the various metallurgical furnaces, in the manufacture of lime, cement and glass, and in the settings of steam boilers.

The last practice, particularly in later years, has demanded a higher grade of brick than was satisfactory under the former milder working conditions. The more general use of mechanical stokers, their greater degree of perfection and the more thorough knowledge by the operators of the theory of combustion, have developed conditions which have made high-grade firebricks much sought for. The development in the manufacture of firebricks has not kept pace with the comparatively more marvelous increase in the severity of service in boiler and stoker installations.

Boiler-Furnace Conditions

With the present modern equipment much improved combustion occurs, much higher temperatures prevail and higher ratings are obtained than were possible with the less intelligently designed and operated installations and boiler and stoker equipment of former years. Whereas some years ago a 50-per cent. overload on a boiler was about the maximum to be expected, it is now not uncommon to see in the larger plants stoker-fired installations operated at 100 to 150 per cent. over their commercial rating.

While not much thought was given to the selection of firebrick in previous years for boiler work, and a brick of mediocre refractoriness would show reasonable life, the best today is none too good under the present extremely severe operating conditions. It is not to be inferred that much progress and improvement have not been made in the manufacture of fireclay brick, as a superior article is today being made by most manufacturers, and continued advancement may be expected.

It would seem from present-day experiences that the capacity of most stoker-fired boilers is limited only by the ability of the firebricks to withstand particularly the extreme temperatures generated. As an example of high temperatures: In some stoker-fired furnaces a quantity of platinum was melted in a graphite crucible, the melting point of platinum being 3191 deg. F. This temperature approaches closely the melting point of pure fireclay, which is 3326 deg. F.

Refractories with High Melting Points

Efforts have been made to substitute materials with melting points higher than the commercial fireclay brick, but because of the inability of these materials to withstand certain other conditions, such as sudden heating and cooling, pressure at high temperatures, the action of certain gases of combustion, and the chemical action of certain fused ash, these substitutions have failed to realize the theoretical expectations. The other refractories that have been given a trial in boiler work are silica, bauxite, chrome and magnesite.

Silica bricks, made from silica rock, or ganister as it is sometimes called, and bonded with about 2 per cent. of lime, have the particular objection for use in boiler-furnace work, especially in arches, of being unable to

withstand sudden changes of temperature without spalling. The lime used as a bond in silica bricks combines with the silica and makes a product that is hard and dense after burning. Although silica bricks are highly refractory and should stand high temperatures, it would not be practicable to maintain, in boiler furnaces, conditions that would be favorable to their long life and general use. In furnace side-walls silica bricks, because they are an acid material, would be readily attacked by the usually basic ash, the ash of nearly all coals being high in ferrous oxide (oxide of iron) which is basic in relation to silica.

Silica bricks would stand the service well with an oil or gas flame, as far as chemical action is concerned, but here again the sudden change in temperature following the sudden turning on or shutting off of the burners would cause a rapid deterioration through spalling. With coal the furnace temperature is not so suddenly reduced, as the fuel bed acts as a reservoir of heat.

A silica brick in comparison with a fireclay brick has a permanent expansion; that is to say, upon repeated heatings its size increases up to a certain point, the rate of increase varying with the different makes of silica bricks. For example, upon the first heating it increases, say, to about 0.04 in., upon the second heating to about 0.03 in., and upon the third to about 0.02 in.—a total of 0.09 in. If, then, it had reached its limit, further heating would increase the size only temporarily, the brick reducing to its final size upon being cooled. The tendency of the firebrick is to become slightly smaller, if anything, upon repeated heatings.

Springs in Arches Unsuccessful

Silica bricks have been used in the arches of heating furnaces in metallurgical operations, and the expansion of the silica arch taken care of by sets of springs placed on the sides of the furnaces at each end of the arches. This is a costly and an annoying arrangement, so we are told, and so far as known is not sufficiently satisfactory to meet with general adoption.

Chrome and magnesite bricks, used in basic openhearth furnaces and other places where the temperature and chemical action is severe, would seem to be ideal for use in boiler side-walls, but because of their inability to withstand much pressure at high temperatures and the heating and cooling effects, these materials are out of the question.

On bauxite bricks experiments are being made to determine their value as a refractory in boiler settings. It has been difficult thus far to make a product of bauxite which will give uniformly good results, by reason of the wide variation in the chemical composition and physical properties of the raw material and the difficulty met with in attempting to control the crude ore. On account of the value of bauxite to the aluminum manufacturer the fields of the best ore are owned by the aluminum industry, and what is available to the brick manufacturer is of inferior quality. Also, more than the usual methods must be employed in reducing the great shrinkage in bauxite, which requires calcining at high temperatures. Bauxite brick, too, is likely to spall.

From the discovered deficiencies of these special refractories—namely, silica, magnesite, chrome and bauxite—for boiler furnace and arch practice, it would appear that the manufacturer who is striving to develop an extraordinarily refractory product for this class of service must confine himself in his experiments to find the proper combination of fireclays.

Selection and Use of Materials

Much trouble with firebrick settings is due to improper selection and ignorance in the use of the materials, and also in many cases to lack of care in constructing and laying up the work. In arches, particularly where the service is hard, care should be taken that all bricks in the same row are of the same thickness and shape, as it is difficult to secure high-grade brick of the same thickness and uniformity. This fact is apparently recognized by the United States Government, which makes liberal allowances for variation in the size of firebrick in its specifications. In a maximum of 9 in. in length it allows a minimum of 8¾ in., although this wide variation should not occur in any one lot of brick and is a variation that the manufacturer would not be proud of.

A conscientious mason will carefully select his brick, culling out those of irregular shape, and will try the selected brick dry over the arch-form with a straight-edge. Then he dips them in a creamy solution of fireclay and rubs them in place. Bricks of uneven thickness should be cut and rubbed. If this care is not exercised large fireclay joints will be required and the life of the arch seriously shortened.

Wedges should be used as often as is necessary to keep the bottoms of the bricks in even contact with the arch form, and the key-brick course should make a true fit from top to bottom. The key brick should be driven from 1 to about 1½ inches, depending upon the hardness of the brick and the width of the arch.

Fireclay Mortar and its Relation to the Life of Firebrick

All firebrick, whether fireclay or special refractories, should be laid in mortar of nearly the same composition as the brick itself to prevent a fluxing action, such as would be caused if, for instance, siliceous mortar were used with magnesite brick. In the case of fireclay bricks, a good grade of fireclay should be used, the refractoriness of which is practically equal to that of the bricks themselves. This precaution is sometimes not taken, with the result that the fireclay begins to melt at a lower temperature than the bricks will stand, and in melting dissolves the bricks adjoining it, much the same as a piece of copper is melted at a temperature lower than its natural melting point when placed in a pot of melted babbitt metal. Inferior clay used in an arch may therefore result in the softening of the bricks and the collapsing of the arch.

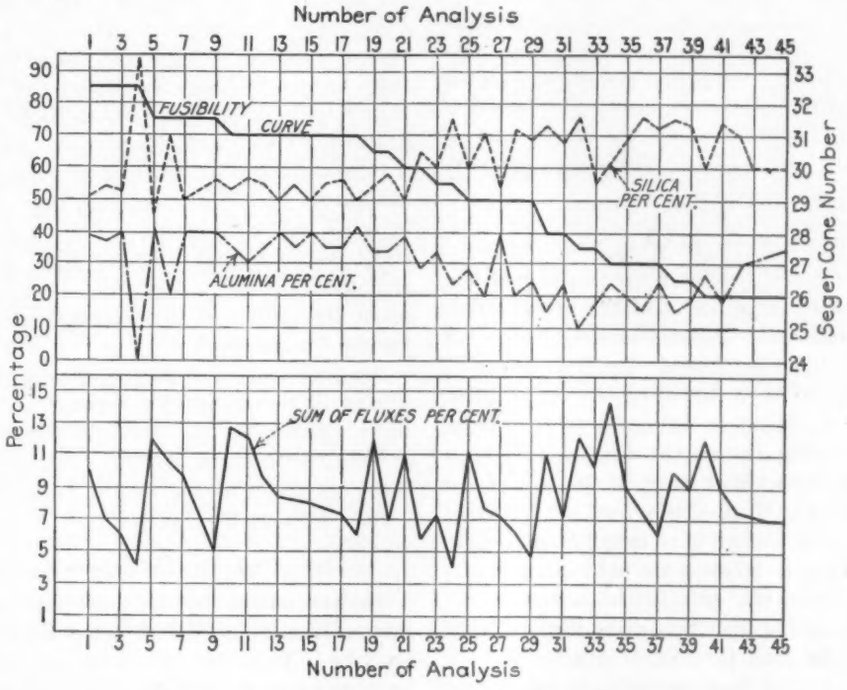
Foreign materials, such as salt and lime, added to fireclay to make it soften and fuse the brick together is, in the manufacturer's opinion, a practice not to be recommended, as both of these materials are active fluxes and readily attack the bricks, especially at high temperatures.

In mixing fireclay to be used as a mortar, best results can be obtained by using a certain amount of fire sand; that is, pulverized calcined clay or bricks. This prevents shrinkage of the raw clay and the crumbling out of the joints. Regarding the benefits derived from boiling fireclay, there is a difference of opinion. Some boil the clay, feeling that it takes out the shrinkage, although there is not enough heat in the boiling process to take out any

appreciable shrinkage; but boiling results in a complete mixture, making it free from lumps and putting it in shape to make a tight job.

Laboratory Tests Compared with Practical Tests

In selecting bricks to be used in furnace practice, the manufacturer is often asked for an analysis of the brick he intends to furnish in order that the user may judge as to its quality. The analysis alone of a brick does not afford the best way to judge its suitability for the work intended, as the analysis merely shows its composition without giving any information as to its physical properties, which are usually more important than the chemical composition. The analysis does not reveal the way in which the impurities occur—an important item in considering the temperature to which the bricks may be subjected without danger of failure. The curves show clearly that the melting point cannot be judged by the analysis alone. On these curves showing the fusibility of 44 different firebricks, the percentage of silica, alumina and total fluxes present in each brick, it will be noted that brick No. 5 melted at Cone No. 31½, or 3200 deg. F., and had 42 per cent. of alumina, 47 per cent. of silica, the sum of fluxes being 12 per cent.; brick No. 21 melted at Cone 30, or 3046 deg. F., and had 50 per cent. of silica, 38 per cent. of alumina, the sum of fluxes being 11 per cent. It would seem from the similarity of these analyses that these two bricks would melt at the same temperature, but owing to the difference in the physical structure one is more refractory than the other.



Results of Analysis of Forty-Four Firebrick

To secure a sample for determining in a laboratory the melting point of a firebrick, the usual method is to knock a corner, about one inch high, off a brick, the bottom of the test piece so secured forming a triangle, each side of which measures approximately one-half inch. This piece, together with three small cones, each having a different known melting point, is then placed in an electric furnace for observation as the temperature of the furnace increases. When the sample piece of firebrick, in the form of a small pyramid, loses its shape, it is considered melted, and the highest pyrometric cone which is melted alongside of the test piece indicates the melting point of the brick. For example, if three pyrometric cones were used, each having a different melting point, say 3218, 3254 and 3290 deg. F., and the 3254 deg. cone was left unaffected, while the 3218 cone was melted at the time the brick sample started to melt, we would know that between 3218 and 3254 deg. F. was the melting point of the sample. This way of determining the melting point has the advantage over other methods using pyrometers, inasmuch as these cones take into account the time element; time should be considered in determining the softening temperature of any fireclay product, as a brick which melts at a high temperature, say in one day, can be melted at a much lower temperature by holding the heat for a longer time.

The melting point is sometimes determined by means of an optical pyrometer. This is also a good method, if all tests are carried out in the same length of time, so as to be comparative.

The temperature at which a piece of firebrick melts in an electric testing furnace is often higher than this same brick will stand in a boiler or commercial heating furnace, as in such furnaces there are conditions, such as the action of the slag and furnace gases, which are not present in the small electric furnace test. On the other hand, in the electric furnace the brick is surrounded by a high soaking-in heat, no chance being afforded for radiation, as is the case with bricks in furnace walls in some types of furnace arches. The service due to heat alone is not as severe on firebricks placed in walls exposed to the atmosphere as in partition or division walls between furnaces, where the heat is acting on both sides of the wall. That this is true is demonstrated by the longer life that arches exposed to the air on one side will show over those subjected to fire on both sides. Although brickwork will show longer life where there is such cooling action, this gain is usually had at the expense of lost heat energy.

United States Government Tests

Another way to determine the softening point is by means of the government load test. This consists in placing a brick on end, loaded 50 lb. per sq.in. of cross-section, and in having it successfully stand a temperature of 2400 deg. F. for one hour without showing any deformation, checking, spalling, or contraction greater than ½ inch in length. In making this test the heat is brought up so that 2400 deg. F. is reached in four hours, and this temperature is maintained for another hour. Another government test consists of breaking up a brick and subjecting the pieces to a temperature of 3200 deg. F., which it must stand without softening. Under the load test, if the brick contains many impurities, its fluxing action will occur at this or a lower temperature and cause the brick to soften, thereby allowing it to compress un-

der the total weight of 562 lb. This load test is better than the melting- or softening-point test, as it shows more clearly the temperature at which the brick commences to soften, and this is the temperature which the user of firebrick, especially firebrick for boiler practice, is interested in. It is also a more comparative test than the melting-point test, as the time element is always the same and it is merely a case of measuring the length of the brick before and after testing to determine the contraction; whereas in the melting-point determination the question always arises at just what point the brick is considered melted, that is, whether it is melted when the tip and sharp corners of the pyramid become rounded or whether it is melted when the piece of brick is seen to distinctly flow, the difference in temperature between these two points being considerable, as the viscosity of most brick is high.

Conductivity of Brick Important

The conductivity of firebrick is a property seldom mentioned in considering brick for boilers; but tests have shown that a hard-burned, dense brick possesses a higher conductivity than a soft, open-grain one. The chemical analysis does not provide information as to the rate at which a fireclay brick will conduct heat, this property depending upon physical makeup.

Some Causes of Failure

A not infrequent cause of trouble in arches is spalling, which is a popping-off of large pieces of the bricks. This sometimes results from arch bricks becoming frozen or wet through a leaky boiler tube, header cap, drum seam or water used in washing out or in turbining the boiler tubes. With this condition unnoticed or unknown to the operators, a hot fire is started before the bricks have been slowly dried, with the result that some, if not all, of the bricks crack and pop off. Once this action is started in any part, the balance of the arch is usually doomed to early destruction. This is because the adjoining bricks are exposed on more than one side to the action of hot gases, more area is receiving heat and more heat is being absorbed by these bricks than they have capacity to take care of by conduction and by final radiation to the atmosphere or a cooler zone of the furnace.

Why Spalling Happens

Spalling, again, may be caused by the natural inability of the brick to withstand the high temperatures of large volumes of slowly moving or confined gases. The ends of the brick are absorbing heat faster than they can conduct it to a comparatively cooler zone, consequently the clay in the exposed ends becomes vitrified, the elasticity of that portion is lost, and when further heating and cooling take place the difference in the rate of expansion and contraction between the two parts of the brick causes a separation, the vitrified section dropping off unless held temporarily by the compression of the arch.

Spalling is also the result of strains due to inrushes of comparatively cold air striking the incandescent bricks and suddenly contracting them. These cold blasts occur when fire-doors are held open too long, or when hand- or stoker-fired grates are improperly operated and large holes in the fuel bed permit a strong draft to pull the cooler outside air into the furnace.

A test sometimes resorted to by prospective buyers to determine the value of a brick for archwork, is one wherein the sample is placed in the furnace, brought up to a red heat, and suddenly dropped into a pail of water. If it does not crack, it is assumed that it will not spall in service. This is no indication of the ability of a firebrick to withstand the heating and cooling strains in an arch, as the conditions are not the same. In heating a brick in an open fire it expands uniformly in all directions, and when thus suddenly cooled the contraction is likewise equal in all directions, whereas a brick in an arch is exposed to high temperature on one side and to comparatively cool gases on the other. When the bricks in an arch are suddenly cooled by a draft of cold air, the upper ends contract at a different rate from the remaining portion.

It is found that a close-grained, hard-burned brick is usually more susceptible to this action than a soft, open-grained, or porous, brick, which is more elastic and better able to adjust itself to this expansion and contraction. The theoretical explanation of this is that in a close-grained, or fine-ground, hard-burned brick, the molecules are more closely associated and heat is more rapidly transmitted from one molecule to the other. Open-grained bricks for this reason act, we might say, more as insulating material, tending to repel the heat instead of absorbing it. When making this comparison we have in mind only such bricks as are made of highly refractory clays, as no matter how carefully a brick may be constructed, if it has not clays of such refractoriness as will resist the action of the temperatures applied, it will be useless for the work.

Another trouble with arches is caused by the improper setting of the skewbacks, through a failure to pack them tight against the buckstays at the sides of the furnace, or using with them, as filling-out pieces, firebrick which come up tight to the buckstays and are set snugly together without fireclay joints.

Allowance for Expansion and Contraction

Arches should be designed and constructed so that they will meet no interference when expanding or contracting. They should not be tied into front-wall brickwork or carry the weight of any other part of the setting. One also should strive to secure as nearly as possible the same conditions both under and above the arch for its entire length. In other words, if an arch within a boiler setting is made a continuation of the dutch-oven arch outside the setting, there is liability of the arch breaking. The extension furnace arch has its upper side exposed to the cooler atmosphere, while the inner arch is in contact with the hot gases of combustion on both sides. The rate of expansion of these two differently located parts of the arch, it is evident, will be different.

Spring of Arch

Arches with too much spring frequently buckle and break their backs when they rise by expansion. A rise or spring of 2 in. to the foot of furnace width is the commonly adopted practice. This gives a reasonable spring to the flatter arch and acts as a resistance to expansion, keeping the arch tight.

Rounding off the last, or end, bricks in an arch frequently lessens or remedies the trouble caused by the spalling off of these ends, and due to the gases making a short, right-angled turn and throwing an intense heat into the

corner of these bricks, which have two of the faces exposed.

Different Brick for Different Parts of Furnace

In considering firebricks for different parts of a furnace, it must be borne in mind that the conditions in side walls are different from those in an arch and that a brick which often gives excellent service in arch practice does not always give correspondingly good results in the side walls of the same furnace. It is therefore well in some cases to use two kinds of brick rather than to try to make one kind do for both places.

Arch practice requires a brick that is not only sufficiently refractory to withstand high temperatures, but one that will withstand these temperatures under much compression, that will not spall and that has a minimum amount of shrinkage and expansion.

In the United States Government tests made on various bricks throughout the country, many bricks were found which would hold up under a temperature test of 3000 and 3200 deg. F. without softening, but only a few, we understand, stood the heat test under pressure.

Furnace side walls are not so much affected by spalling as they frequently are through the chemical action of the fused ash and distilled gases of some coals. Generally speaking, where coal is used as fuel, furnace side walls require a brick less porous and soft than would be used in an arch, in order to stand abrasion from the fire tools and the cutting action of the clinkers when being disturbed or removed.

Arch Blocks

Blocks for arches and side walls are sometimes used and in many cases give better results than standard 9-in. brick. They have the advantage of reducing the number of joints and parts to lay, and the radial arch blocks turn true to the given circle. These blocks are usually made on special orders of a certain combination of clays, are tried for fit, and by some manufacturers machined down, where necessary, on a carborundum wheel to secure level sides and to insure a good fit. On account of the greater mass of contained material, these blocks must be carefully and slowly dried on a cool floor and painstakingly burned.

Turbo-Reduction Gear

The planetary type of gear shown in Figs. 1 and 2 is a recent development of the Turbo-Gear Co., Baltimore, Md. It is designed to be used as a speed-reducing or speed-increasing gear and will run either right- or left-hand. The driving and driven shafts rotate in the same direction.

The gear consists of a large internal double-helical gear made of an openhearth steel forging. A double-helical pinion cut integral with the high-speed shaft is made of chrome-vanadium. The intermediate double-helical gears are made of manganese-bronze and are mounted on hardened and ground forged-steel shafts which are secured to the cast-steel slow-speed member by means of a taper fit and Woodruff keys.

The slow-speed member to which is secured the slow-speed shaft is mounted on two heavy-duty ball bearings, one on each side of the gears, and supported directly by the heavy housing. The slow-speed member, the shaft carrying the intermediate gears and the high-speed shaft and pinion are independent of each other for support and each is supported directly by the housing.

The housing is made of cast iron, horizontally split to afford accessibility to all internal parts. It is heavy and well ribbed to provide a rigid support for the gear members in order to secure quiet operation. Caps protect the high- and low-speed bearings from dust.

The high-speed shaft has a central passage through which the oil is pumped, and a continuous stream is sprayed on the gears through radial passages in the pinion. The high-speed bearings, besides having forced-feed lubrication, are provided with oil rings and an oil reservoir for emergency use. The superfluous oil from the high-speed bearings is collected by a centrifugal oil ring and forced through the hollow shafts carrying the intermediate gears, flushing their bearings. The oil, after lubricating the bearings and gears, is immediately drained to the main oil reservoir in the base of the housing; here it is strained, cooled, returned to the pump and used over again.

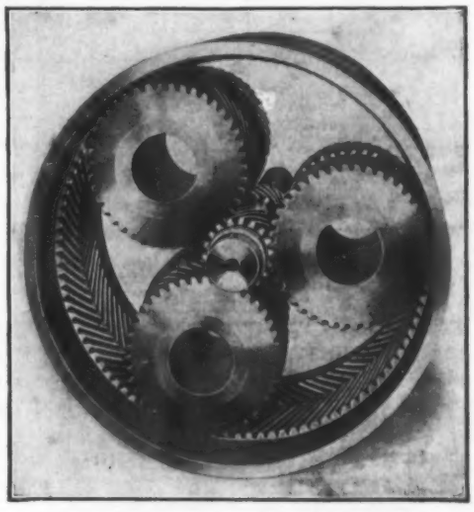


Fig. 1. Turbo-Reduction Gear

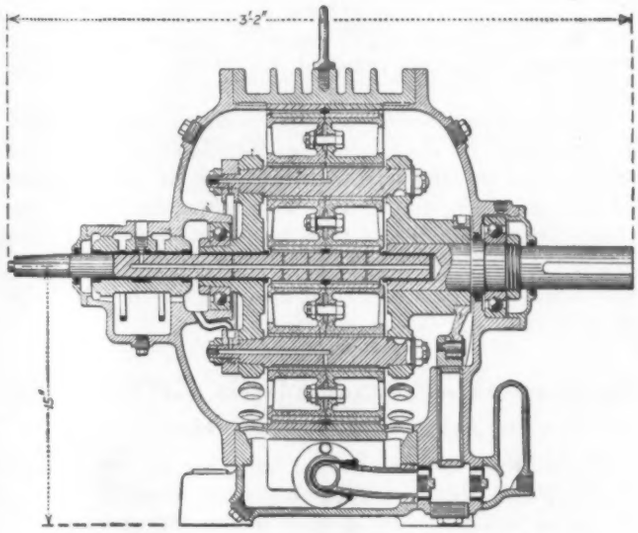
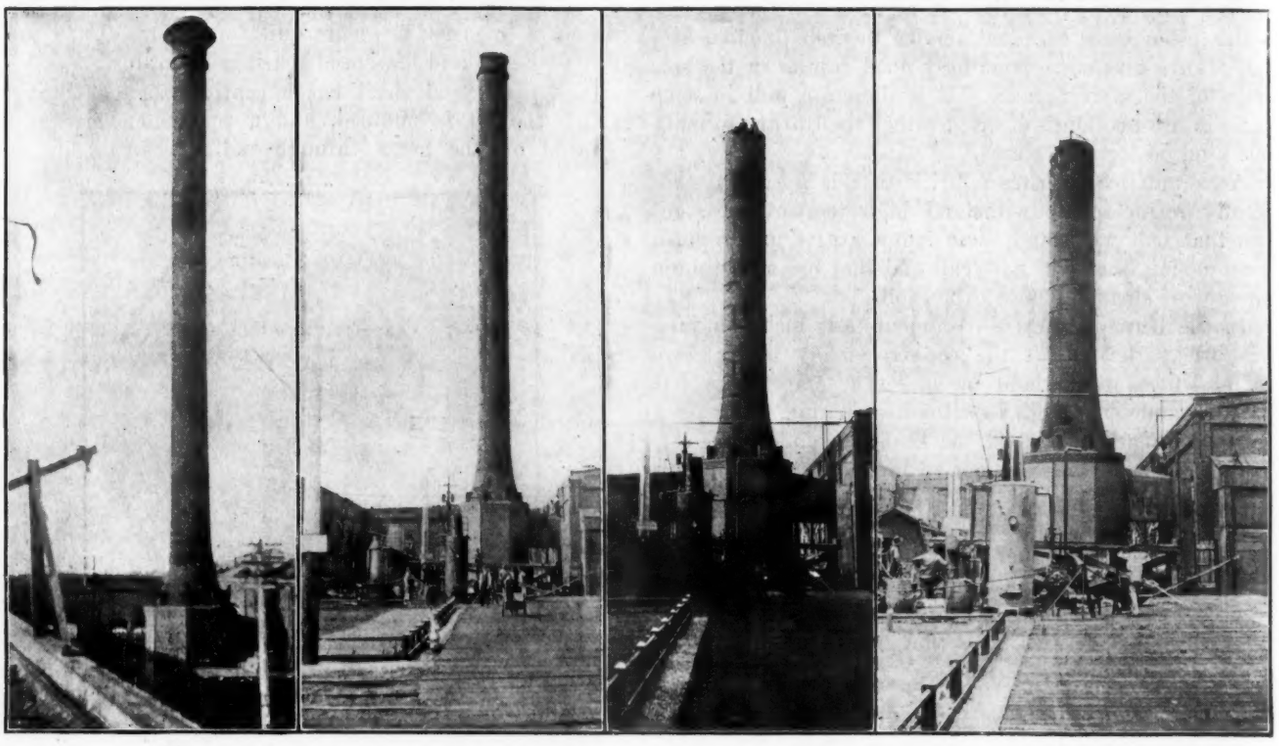


Fig. 2. Section through the Turbo-Reduction Gear

Cutting Down a Steel Stack

On Apr. 20, 1915, the St. Louis & San Francisco R.R. began removing the smoke-stack at its North Springfield shops. This stack was 146 ft. high, 8 ft. in diameter and composed of sheets $\frac{7}{16}$ to $\frac{5}{16}$ in. thick.



Removing a Steel Stack with the Oxyacetylene Torch

Seventeen rings were removed, the height of each being 56 in.

Oxyacetylene was used in cutting down this stack, says E. W. Allen in the *American Machinist,* at a cost of $283.73 for gas and labor. On account of the condition of the stack, it would have cost approximately $500, if any other method had been employed and would have taken 17½ days to remove it. By using oxyacetylene it was removed with a saving of about $216, and the work completed in six days.

Ingersoll-Rand High Efficiency Air Compressor

The constant demand for higher efficiency and greater economy and the increasing tendency towards the use of higher steam pressures have led to the development by the Ingersoll-Rand Co., 11 Broadway, New York City, of an improved small steam-driven, high-speed air compressor.

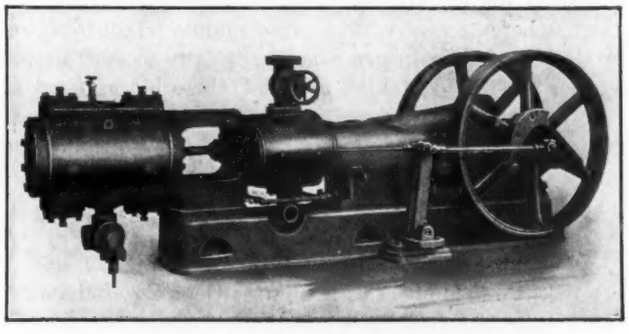
The machine is designed along the same lines as the company's former small steam-driven type, but embodies many improvements which give it a higher efficiency in the air end and a considerably lower steam consumption in the steam end. These improvements are as follows:

The adoption of the Ingersoll-Togler air valves, which allow of high speeds, give high compression efficiency, are almost silent in operation and are independent of any operating mechanism.

Balanced-piston steam valves, designed after the most advanced European practice, permit of high speeds, high steam pressures and the use of superheated steam, at the same time giving a higher efficiency under ordinary low-pressure steam conditions.

An automatic cutoff control gives high steam economy under conditions of varying load or varying steam pressures. This control is regulated by a centrifugal flywheel governor which acts to shorten or lengthen the stroke of the piston valve, thus changing the cutoff.

All wearing parts are copiously and automatically oiled by means of automatic splash lubrication, and inclosed



Steam-Driven Air Compressor

construction and removable covers make for cleanliness with great accessibility.

The machine is designed and constructed with special attention to rigidity without excess weight. The bearing surfaces are large and special provision has been made for ready adjustment of all parts, without loss of time.

The automatic cutoff control is supplemented by an air unloader, which assures economy while possessing a high degree of automatism, which is essential in a small compressor designed for severe duty, and generally subject to considerable neglect.

Editorials

Fruits of the Locomotive Boiler Inspection Law

The most cheering part of the paper on "Fruits of the Locomotive Boiler Inspection Law," read before the Western Railway Club by Frank McManamy and published elsewhere in this issue, is that the number of serious locomotive-boiler accidents is decreasing, not because of the application of appurtenances simple or automatic, not because money is being invested in this and that contrivance, but just because the law promotes more thorough maintenance and greater carefulness of operation. Yes, of course, this could have been done without the law. But it was not. And therein lies the chief force of any good boiler-inspection law.

"No railroad man," says Mr. McManamy, "with knowledge of conditions and practices prior to the passage of the law can question the fact that, generally speaking, inspections are now more carefully and more regularly, and repairs more promptly, made, and the question of repairs is less apt to be determined by the number of loads in the yard awaiting movement."

There is just as much morality and altruism in railroad men as in any other class. And it is with due appreciation of these virtues that we remark that the improved conditions mentioned by Mr. McManamy exist because the potential offenders know that they are being watched more closely now than before the passage of the law. The same is true in stationary practice.

Most of us are good anyway, but if we know we are being watched we are better. We admit this to ourselves, but seldom to others.

This looseness or carelessness often manifests itself in acts or conditions that cannot be said to be due to exigencies of the service, or to sacrifice of safety for convenience, or to the erroneous idea of saving money by putting off the day of spending it in needed repairs to parts in dangerous condition. This kind of laxity is detestable, because it is void of reason and inexcusable.

For example, during the last fiscal year the department records show that eighteen persons were injured by studs blowing out of fireboxes or wrapper sheets. Doubtless most of them gave long and ample warning, by leaking, that they needed renewing. It is also true that, usually, they can be renewed more cheaply before blowing out than after. But no, they are tinkered with. They are calked or neglected altogether until finally they blow out.

For this sort of psychological phenomenon no boiler law can of itself do any good. The attitude of mind that allows this condition to continue can be cured only by education, whether it comes by persuasion and reason or is got by the offender-victim being nearly killed before he learns his lesson.

That some opponents of boiler-inspection laws still offer the argument that all boiler explosions are crown-sheet failures, therefore man failures and not preventable through law, is evident from one of Mr. McManamy's statements. Of course such a contention is mere froth. In the locomotive-inspection service during 1914, as compared with 1912, crown-sheet failures decreased forty-eight per cent. and the number killed, sixty-four per cent.

From Mr. McManamy's paper it appears that on some locomotives the location, relative to the highest point of the crown-sheet, of the bottom fittings for gage-glasses constitutes a menace.

It is difficult enough, owing to grades, curves and stops, to keep the crown-sheets of locomotives covered at all times, even where the glasses are conveniently and properly located, and to put them elsewhere is nothing short of criminal. On a busy division particularly, an engineer has so much to watch along the right-of-way that simply a glance from his seat should enable him to see the water level. But we learn that on some types of locomotives the engineer must leave his seat to see the water level, and on others must step back out of reach of the throttle, brake valve and reverse lever to try the gage-cocks. The strongest condemnation of these conditions is too mild.

Happily, the aim of all is to reduce the hazards and attain better conditions generally. And the law is responsible for the movement.

Clean New Steam Lines

In our issue of June 8, on page 785, we printed a letter from E. E. Strong, president of the Strong, Carlisle & Hammond Company, calling attention to the importance of seeing that new steam lines are clear of grease, white lead, iron filings and dirt of all kinds before they are put in use, so that foreign matter may be kept out of separators, reducing valves, steam traps, and all other devices.

The necessity of doing this seems so self-evident that it hardly would appear that comment on the subject was called for, but inasmuch as a man of Mr. Strong's experience has found that carelessness in this particular is common, we feel the importance of calling attention to it on this page, in an effort to do as Mr. Strong suggested—start a campaign of education along the lines of showing the importance of clearing steam lines before they are put in use.

There is a saying somewhat to this effect, although not in exactly the same words, that "the man who would not put dirt in the works of his watch would nevertheless put things into his stomach which are equally bad for that organ." The author of this remark might have gone further and added that the man who takes great pains to keep the brasswork on his engine polished, and other things about his plant neat, will sometimes do just such careless things as to connect up a steam line with lengths of pipe that have lain where they could accumulate dirt and rust in the interior, or that possibly are fouled with chips from threading, without first blowing these lines out with steam before connecting to

them anything so susceptible to injury from foreign particles as a separator or a reducing valve or even a steam trap.

Surely this is one of the big little things about a steam plant that the engineer in charge should give his personal attention to, whether the work is being done by outside help or by his own force, so that no pipe connections may be made in such a way that there is any risk of foreign matter getting into the system.

License Committees Take Notice

When the framers of the present New Jersey license law had completed their task, with the assistance of an attorney, no one of the many who looked over the bill could find fault with it. When the license bureau began its work, however, a defect showed itself.

The law states that "provisions of this act shall not be construed to include or apply to" marine engineers, engineers in plants under the jurisdiction of the United States, nor locomotive engineers. They were and are willing to be examined and pay for licenses, but the attorney-general says that they cannot lawfully be granted licenses. They are now aggrieved and protest vigorously.

The import is far more serious than appears on the surface. The wording of the law is such that an engineer holding a license to run a dinky tugboat may operate the largest and most complex stationary plant in the state and be immune from any action that the license bureau may see fit to take.

This is important, and license committees should take a lesson from New Jersey's error.

The Firebrick Problem

Obtaining the investment and operating advantages possible with high boiler ratings has confronted the engineer with high-temperature problems that, while serious, are being admirably met. Procuring the most suitable firebrick for given conditions is only one of these problems, but it is so far the one furthest from a satisfactory solution.

The engineer may, after tests and experience, select the most suitable of available bricks, but it is the manufacturer's function to produce bricks that will meet the extremely high temperatures associated with modern boiler-room practice. When a boiler is operating at from two hundred to three hundred and fifty per cent. of rating, the furnace is filled with a dazzling white gas and the temperature approaches three thousand degrees Fahrenheit. This is within a few hundred degrees of the temperature at which pure fireclay will melt.

With the widely fluctuating furnace temperature, the bricks are subjected to severe expansion and contraction. Arches frequently have extremely high temperatures on one side and comparatively cool gases on the other; side walls are affected by the chemical action of the fusing ash; and poor clay, when between joints, soon drops out, exposing the brick to a soaking-in heat. And so it goes, the sources of trouble being numerous, and greatly increased if the masonwork is not of the best.

Notwithstanding the seriousness of the firebrick problem, it is a fact that little really useful information relative to it has been published. The article elsewhere in this issue is one of the best general ones that has come to our attention. It is replete with information that any engineer can use, whether he operates at a high or a low rating, or a large or a small boiler plant.

But it is not enough. There are many plants where the firebrick problem has been, and is now being, investigated and the need for immediate dissemination of results is urgent. Those who have investigated extensively and discovered and compiled truly useful and applicable information should give others the benefit by making it available for publication.

Does the Amended Massachusetts Law Discriminate?

We have just received a communication which brands as discriminative the Massachusetts license law as amended. As told editorially in our issue of June fifteenth, the law was amended to allow plants operating the major part of the time by water to be in charge of an engineer holding a special license. The writer of the letter wishes to know why plants having waterwheels should be so favored, while the same liberties are not extended to plants run by electric motors, driven by purchased current the major part of the time.

If the danger is no greater in one case than in the other, then there is no reason why the plant operated most of the time by electric motors, but only part of the time by its own high-pressure-steam-driven machinery, should not be allowed to be operated by a man holding a special license. Where none of the engines and boilers in such a plant is not of greater capacity than one-hundred and fifty horsepower, a special license will cover the plant. But if any of the engines or boilers are of greater capacity a first-class engineer must be in charge, though the plant is driven most of the time by purchased current.

Technically, it is easy to show that the amended law is discriminative in favor of water power, but plants operating on purchased current most of the time and running their own engines and boilers some of the time are few. The condition rarely exists, because when an industrial plant uses purchased current it uses it exclusively or only on overloads, which are carried by new equipment just as soon as the latter can be advantageously installed. Of course, breakdown service is available in some plants, but, as its name implies, it is only for emergencies.

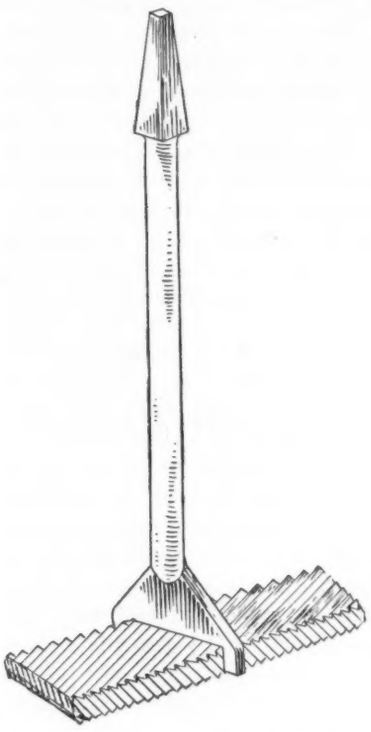
It is not at all likely that serious trouble will follow the discovery of this technical discrimination, because there are few, if any, such plants in existence to be discriminated against. In plants such as our correspondent has in mind, the owner will find it good business to keep a thoroughly competent man in charge, regardless of what the law allows him to do. The law will allow you to take your watch to a blacksmith for repair, or get your hair cut by a gardener who trims the hedge, but you would not take advantage of either opportunity.

Efforts are being made before the New York Constitutional Convention to have the Public Service Commissions made constitutional bodies surrounded with all the safeguards afforded the courts. There are few departments in the state government wherein personal integrity and moral courage count for more, and any step that will help to render the public service commissions free from personal or political influence is commendable.

Correspondence

To Smooth a Valve Seat

A 1-in. globe valve, although nearly new, gave trouble by leaking. It was in a rather dark corner, so for a long time it was not noticed that the valve seat had become roughened from some cause. When discovered, the first thought was that a new valve would be necessary, as we had no tools at hand for dressing the seat, but a piece of flat file short enough to be turned around while lying flat on the seat did the work. A contrivance for rotating the file was made from the shank of an old wood bit, flattened and shaped as shown in the illustration. With this tool in a common bit brace, the valve seat was quickly made as smooth as when new.



VALVE SEAT SMOOTHING TOOL

G. E. MILES.

Denver, Colo.

Engineer Killed in Peculiar Turbine Accident

About the middle of last month a turbine connected to a 250-kw. generator in a cold-storage plant in New York City wrecked itself and instantly killed the engineer in charge. The cause of the accident is not definitely known nor the circumstances leading up to it, as the engineer was alone in the room at the time. From indications, however, it is believed that the bearing-cap on the end of the shaft next to the rotor had become loosened and that the engineer was tightening or adjusting it at the time. The shaft was 1⅝ in. diameter and ran at 9000 r.p.m. It was impossible to tell from the wreckage whether it was the shaft or the bearing which gave way first, as both were badly broken up.

The duty of this set was particularly severe, as there was no duplicate machine and it was kept in constant operation, except a stop of half an hour on Sundays, so that most of the adjustments which were made had to be done while the machine was in service. This accident demonstrates anew the extreme risk to man and machinery of making even minor adjustments not intended to be made while the machine is in motion, and especially so when operated at such high speed.

WILLIAM SOUTHARD.

New York City.

Notes on Alternating- and Direct-Current Motors

In the May 4 issue under the caption, "Interior Wiring for Lighting and Power Service," Mr. Cook makes some statements that are not quite up to the latest practice. First, in reference to the voltage employed by alternating-current motors, he states that in some cases for very large motors 2200 volts is used. Now 2200 volts is commonly used and 6600 and 7500 volts are occasionally used for large motors. Probably the most notable 6600-volt induction-motor installation is the three 6000-hp. machine group in the rail-mill department of the steel works of the U. S. Steel Corporation, at Gary, Ind. A description of these motors was published in POWER in the issue of Apr. 5, 1910. In a recent steel-mill installation 6600-volt induction motors have been used throughout; the machines ranging in size from 350 to 3000 hp. and aggregating approximately 12,000 hp.

Another important installation is the 300-hp., 7500-volt induction motors used to drive the exciters in the new power house of the United Electric Light & Power Co., New York City.

If we include synchronous condensers and frequency changers in this category, it will be found that the voltage is even higher, as there are a number of 11,000- and 13,200-volt synchronous motors in operation in this country; probably the highest-voltage machine of this type being the 16,500-volt, 6000-kv.-a. synchronous condenser used for power-factor correction by the Southern California Edison Co., of Los Angeles. What in all likelihood is the largest frequency changing set in service today is that installed to interconnect the Boston Elevated and Boston Edison systems. This set consists of a 13,200-volt, 25-cycle unit rated at 9000 kv.-a., and a 13,800-volt unit rated at 9000 kv.-a.,

Secondly, with direct-current systems it is possible to obtain motors that will allow a speed change of 3 to 1. One of the latest productions of the electrical industry is an adjustable-speed reversible direct-current motor for metal planers and slotters, having a speed range of 250 to 1000 r.p.m. by field control; these machines have been standardized up to 50 hp. Motors for continuous service, with a speed range of 4 to 1, have been built in sizes up to 125 hp., and 225-hp., 500-volt machines with a speed range of 225 to 675 r.p.m., or 1 to 3. Moreover, 115-230-volt machines may be had with a speed range of 1 to 6 in sizes up to 25 hp. continuous-service rating, or 45 hp. intermittent-service rating.

Thirdly, Mr. Cook appears to use the terms "adjustable-speed" and "variable-speed" alternating-current

motors synonymously, whereas they mean two different types. The variable-speed machine is one in which the speed is constant for constant load, but varies with the load, accelerating with light loads and dropping again when the load comes on, as in a direct-current motor with armature control or a phase-wound rotor polyphase induction motor with rheostatic control. Adjustable-speed machines are those in which the speed remains approximately constant at any adjustment, irrespective of the load. One of the best examples of this type is the direct-current shunt motor with field control. Until recent years only direct-current motors were available for strictly adjustable-speed drives, which is also true today for small motors where wide ranges of speed are required. However, during the past eight or ten years schemes have been developed for adjusting the speed of alternating-current motors, so that now the adjustable-speed polyphase induction motor in many cases compares favorably with the direct-current machine, especially in large units for rolling-mill drives, mine fans, etc., and in some cases it shows an advantage over the direct-current machine. For example, in 1913 a 600-hp., 2200-volt adjustable-speed polyphase induction-motor set for driving a rolling-mill was installed, having six different synchronous speed adjustments between the limits of 300 and 500 r.p.m. This set consists of two machines arranged so that they can be connected in cascade. The primary motor has a phase-wound rotor with its stator wound for 14 and 16 poles; the secondary motor is a squirrel-cage machine having its stator winding arranged so that it can be grouped for 4- or 8-pole connections. It is worthy of note that this set was chosen in preference to a direct-current machine, and that it has proved very satisfactory in service.

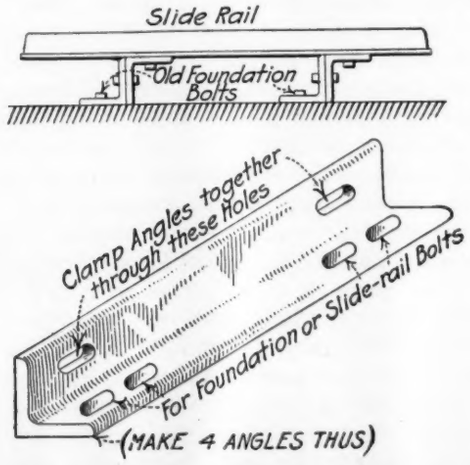
A. A. Fredericks.

New York City.

Realigning a Belt-Driven Generator

The illustration shows a method I used in realigning a belt-driven exciter so the belt would not slip off under heavy load.

The material required consists of four pieces of angle iron selected in proportion to the size of the machine. The combination of lateral and transverse slots gives freedom of motion to square up the machine. For ordinary aligning four symmetrical angles will do. However, should a machine have to be shifted endwise considerably, slots can be cut in the foundation angle bars.


Slide Rail
Old Foundation Bolts
Clamp Angles together through these Holes
For Foundation or Slide-rail Bolts
(MAKE 4 ANGLES THUS)

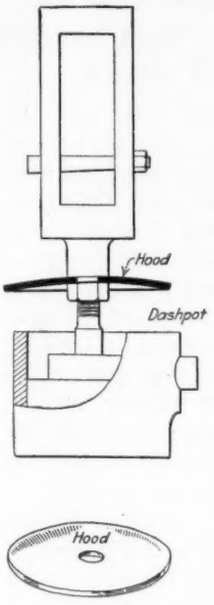
Material for Mounting Generator

Fred E. Walchli.

Kalispell, Mont.

Hood over Dash Pot

We had considerable trouble in keeping the latch blocks and plates in good condition and the cutoff equalized on a Brown twin-engine. It was impossible to maintain an equal cutoff or equal distribution of the load between the two sides.



Hood in Place

The valve-stem stuffing-boxes being very shallow, it is difficult to prevent some leakage, and most of the time there is more or less water dripping into the dashpots. A sort of drip cup is provided under the stuffing-boxes, intended to catch and carry off the leakage, but it is of little value. It is desirable to keep water away from the valve gear because it washes off the oil, but there is no room to put a shield where it will do the most good. I therefore arranged a sheet-metal hood over each dashpot, as shown in the illustration. Previous to this we were tinkering with latch blocks and plates and adjustments continually, but now the engine runs for months without requiring more than slight adjustments to the valve gear.

H. L. Strong.

Yarmouthville, Maine.

Reversed Field Coils

The terminals of some field coils are so located that if the coil has been turned over or turned end for end while installing, the appearance of the terminals makes the mistake evident. There are coils, however, which may be inverted without the appearance of the terminals suggesting any irregular condition. The terminals of such coils are located in the centers of opposite sides or of opposite ends, and the coil appears the same irrespective of the manner in which it may have been installed. Any such mistake which results in the current circulating in the wrong direction will reverse the polarity of the coil, and if the number of reversed coils is a sufficiently large proportion of the total number, the machine will be unable to build up its field. At all events, the voltage obtainable will be reduced and commutation will be impaired.

An inspector was called to locate the trouble in a generator that was unable to build up its field; even when the machine was separately excited from another, the value of the voltage obtainable was very small. The machine had been in a flood and had been disassembled for cleaning. The operator stated that he had marked the field spools when removing them and that he had

replaced them just as they had been marked. He evidently either had marked the spools incorrectly or had failed to observe the marks carefully while reassembling, because on raising the brushes, exciting the field from another machine and testing the polarity with a nail, all the bottom poles were found to be of the same polarity.

The terminals of the field coils were in the centers of opposite ends of the coils and two alternate coils had been installed end for end, thereby reversing two coils out of five and making five consecutive similar poles. An inspection of the direction arrows stamped on the flanges of the field spools confirmed the supposition.

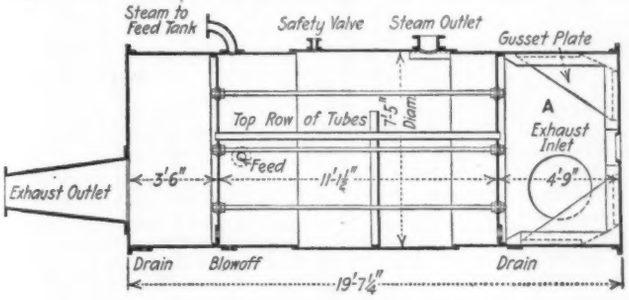
Where the marks on the flanges are not plain or where there is any doubt as to how a coil should be placed, the best plan is to temporarily place and connect the coil and test the polarity with a nail or compass. Where a compass is used by an inexperienced person, it is best that the test be made with the armature withdrawn; otherwise, the poles induced in the armature core by the polepieces may cause misleading results.

E. C. PARHAM.

Schenectady, N. Y.

Exhaust-Gas Heated Boiler

In one of the power houses of a large engineering works where gas made from bituminous coal supplied the motive power, the heat from the engine exhaust was utilized to generate the steam supplied to the gas producers. The plant was run with the ammonia-recovery process, thus requiring 1 to 1.25 lb. of steam for every pound of coal



SECTION THROUGH BOILER

used. Three 1000-hp. engines and exhaust boilers were to be installed, although only one unit was at first put in.

The exhaust pipe was 30 in. in diameter and had two gate valves arranged so that the gases could be led either to the boiler, from which they entered a large masonry chamber, or silencer, built in the ground, or they could travel directly to the silencer.

The sketch shows the boiler, which evaporates 2.5 lb. of water at 100 lb. per sq.in. per brake horsepower delivered by the engine. It was of horizontal cylindrical construction, 19 ft. 7¼ in. in length and 7 ft. 5 in. least internal diameter, the sides being ½-in. plate and the ends of ⅝-in. plate; the tube-sheets were ¾ in. There were 182 tubes, 3¼-in. outside diameter at 4½-in. pitch, giving over 1700 sq.ft. of heating surface. The tube sheets were stayed by seven 1½-in. stays, and midway the tubes were supported by a plate cut out at intervals around the circumference to permit of freer circulation of the water.

The exhaust gases entered the firebrick-lined compartment shown and, after passing through the tubes, entered a 3½-ft. compartment, also supplied with a manhole and drain, and then through a 30x18-in. reducer to the silencer. The working level of the water was about 4 in. above the top row of tubes.

The boiler was fitted with the usual safety valve, manhole, steam and water gages, a 3-in. steam connection for heating the feed-water tank, a 3-in. feed inlet, a blowoff valve and mudholes, and was connected to the gas producers by an 8-in. steam line. Below the steam opening in the boiler was a ⅛-in. copper plate clearing the opening by 2¾ in., for preventing priming. The heating surface of the tubes was 1723 sq.ft.

G. MOORE.

Newark, N. J.

An Emergency Gasket

The lead gasket illustrated and described by F. W. Reynolds in the issue of May 25, on page 725, has been used with fair success under different conditions for many years. A light piece of lead pipe is often employed for the same purpose. Such a gasket may be improved by drawing into the pipe a piece of asbestos rope to act as an equalizing cushion.

JAMES E. NOBLE.

Toronto, Ont.

Wrong Stator Connections

If the stator coils of a three-phase induction motor are delta-connected, each will be subjected to the full line voltage; if Y-connected, however, each pair of line wires will include two stator coils in series, in which case the voltage per coil will be approximately 0.58 of the line voltage. Moreover, in a Y-connected stator the current of the line and of each coil is the same, whereas with the delta connection the line current divides between two paths. The operating characteristics of the motor will vary accordingly as one or the other of these connections is used, because the resistances and reactances involved differ in the two cases.

For several years a three-phase induction motor had successfully driven the compressor used for storing with compressed air the whistle-blowing reservoir of a fire-alarm system. Owing to continuous neglect of the automatic governor, abnormal pressures obtained at times, with the final result that the stator burned out. It was rewound, after which, firemen in the outlying districts began to miss fires and invariably gave the excuse that they had not heard the whistle. Repeated trials proved the excuse to be well-grounded; the whistle was inaudible in districts where it could be plainly heard, even if an opposing wind were blowing, before the stator was rewound.

Investigation disclosed that the motor was heating abnormally and that it could store against only 60 lb. pressure, whereas it formerly had been able to store at 100 lb. without any distress. Checking of the rotor speed showed the slip at 60 lb. to be 240 r.p.m. On a normal motor the slip would not have exceeded 60 r.p.m. The end shield was then removed and the connections inspected, and it was found that the coils which were bought for the rewinding were greater in number and had smaller wire than those of the original winding. The repairman had installed the new coils in the same manner

as he had found the old ones, and in the absence of instructions he was justified in doing so. The original coils were Y-connected and the new ones were also, but they should have been delta-connected.

J. A. Horton.

Schenectady, N. Y.

A Mistaken Notion

I observed an engineer carefully pointing a pine plug to drive in as a substitute for a pump-cylinder cock that was lost. Inquiry developed that he believed the steam would have less chance to blow the pointed plug out than if the end was blunt.

Since then I have heard others pull off the same line of argument. It is true, of course, that if steam or water is issuing with considerable force a pointed plug may be more easily entered, but that is "another story." I hope I will not be classed as a "plug fitter" by reason of the foregoing observations.

A. E. Baker.

Cambridge, Ohio.

Indicator Showed Leaking Piston

Diagrams taken from a 9x16x24-in. Corliss engine with the low-pressure cylinder disconnected for experimental work showed a peculiar back-pressure line. The

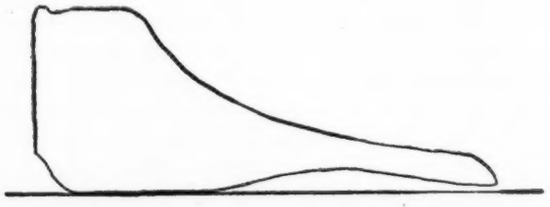


Fig. 1. Diagram Indicates Leakage

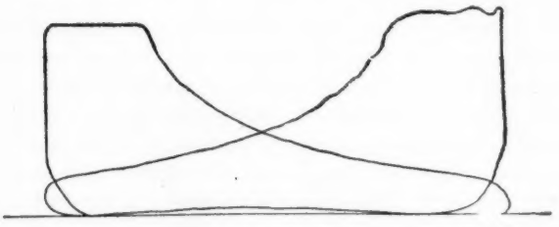


Fig. 2. Condition after Increasing Tension

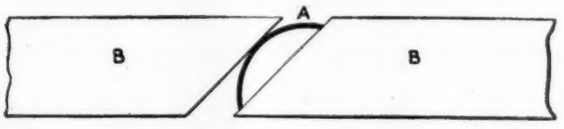


Fig. 3. Steel Spring to Give Tension to Ring

hump in the exhaust line, shown in Fig. 1, would appear on the head end for a day or so, then show up on the crank end for a few days, and then back to the head end again, owing to some change in the position of the piston ring.

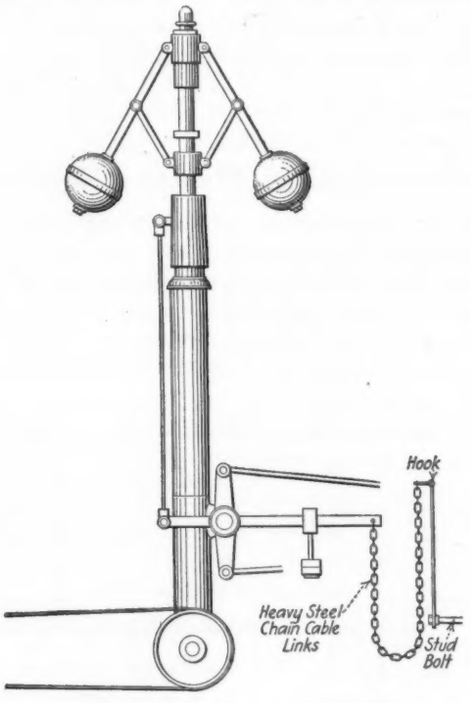
A piece of heavy clock-spring was filed and peened to fit, as shown at *A*, Fig. 3, and just long enough not to bind when the ring was compressed. The joint was open about $\frac{3}{16}$ of an inch when compressed to the cylinder size, allowing sufficient clearance for the spring. Before inserting the piston in the cylinder the joint of the ring was turned to the top of the piston to prevent spring *A* working loose and cutting the cylinder. Other diagrams were taken after this change, with results as shown in Fig. 2.

William Smith.

Union Hill, N. J.

Corliss Governor Compensator

The accompanying illustration shows a chain compensator for a Corliss engine governor. The chain has all of the advantages of a gag pot, and in addition the governor will take hold quicker in bringing an engine up to speed when starting up than if a gag pot is used.



Chain Compensator for a Corliss Engine Governor

When the governor balls are in their lowest position the major part of the chain pulls down on the lever, and when the balls are in their highest position the major part of the chain is supported by the standard.

C. E. Bascom

Westfield, Mass.

Storm Demolished Two Stacks

On the night of May 27, a storm blew down the two 30-in. x 75-ft. smoke-stacks of the Moberly artificial ice plant at Moberly, Mo. Only one boiler was in use at the time, and, strangely, the 1¼-in. water-column pipe was torn out from that boiler, blowing all the water out. The stack fell in such a way that it did not damage the building or equipment except as stated.

C. F. Doehring.

Moberly, Mo.

Inquiries of General Interest

Weight of Spanish Libra—What is the relation between the weight of the Spanish pound used in Latin-American countries and the avoirdupois pound of the United States?

P. P. C.

The Spanish "pound," or more properly "libra," is equal to 1.0161 United States avoirdupois pounds, or 1 lb., 0.2676 oz.

Capacity of Pump—What is the capacity, in gallons per minute, of a duplex steam pump with water cylinders 6 in. diameter, when running at a piston speed of 90 ft. per min.?

E. P.

Without allowing for reduction by presence of the piston rod, the piston displacement in each water cylinder would be

$$(6 \times 6 \times 0.7854) \times 90 \times 12 = 30{,}536.35 \text{ cu.in. per min.}$$

and, without allowance for slippage, the combined pumpage of two water cylinders would be

$$(2 \times 30{,}536) \div 231 \text{ cu.in. per gal.} = 264.4 \text{ gal. per min.}$$

and, allowing 5 per cent. slippage, the delivery would be

$$264.4 \times 0.95 = 251.18 \text{ gal. per min.}$$

Factor of Evaporation with Superheated Steam—What would be the factor of evaporation in the generation of steam at 135 lb. gage pressure with 100 deg. of superheat, from feed water at 200 deg. F.?

R. J. F.

A gage pressure of 135 lb. per sq.in. would be equivalent to about 150 lb. absolute, and by reference to Marks and Davis' Steam Tables it is found that a pound of steam at 150 lb. absolute, when superheated 100 deg. F., contains 1249.6 B.t.u. above 32 deg. As the latent heat of steam at 212 deg. F. is 970.4, then, as compared with evaporation from and at 212 deg. F., the factor of evaporation would be

$$\frac{1249.6 - (200 - 32)}{970.4} = 1.1146$$

Testing Flow of Steam—How can a test be made of the weight of steam used by a small steam pump?

W. L. B.

If one of the several types of steam meters is not available, a close approximation to the rate of flow can be determined for a stated pump speed and other operating conditions by placing a gaging stop valve in the steam line to the pump and ascertaining the flow that takes place through such a valve under the same conditions of valve opening and pressure on each side of the valve as when the pump is in operation. For the purpose, place a pressure gage on each side of the valve and, with the gaging valve partly closed, observe the indication of each pressure gage while the pump is in operation. Then, with the pump shut down, determine, by increase of weight, the rate at which the steam condenses when discharging without loss into about three-fourths of a barrel of water, having the same opening of the gaging valve and same readings of the pressure gages as when the pump was in use. The pressure on the discharge side of the stop valve can be regulated by throttling the escape of steam to the condensing water.

Relative Economy with Different Initial Pressures—What would be the relative economy of employing steam at an initial pressure of 75 lb. and at 100-lb. gage pressure per sq.in., if in each instance the clearance is 5 per cent., cutoff at ¼ of the stroke, the average back-pressure 4 lb. gage and the boiler-feed water 200 deg. F.?

G. K.

By referring to a table of mean pressures per pound of initial pressure with different clearances and points of cutoff (such as given on page 115 of Low's "Steam Engine Indicator"), it may be seen that with cutoff at ¼ stroke and 5 per cent. clearance, the mean pressure per pound initial absolute would be 0.6258 lb. Therefore, with an initial pressure of 75 lb. gage, which is equal to about 75 + 15, or 90, lb. absolute, and back-pressure of 4 lb. gage, or 4 + 15 = 19 lb. absolute, the mean effective pressure would be

$$(90 \times 0.6258) - 19 = 37.322,$$

and with an initial pressure of 100 lb. gage, or 115 lb. absolute, and the same average back-pressure, the mean effective pressure would be

$$(115 \times 0.6258) - 19 = 52.967 \text{ lb.}$$

As the density of steam at 90 lb. absolute is 0.2044 lb. per cu.ft., and of steam at 115 lb. absolute is 0.2577 lb. per cu.ft., then for the same cutoff and same diagram factors the relative weight of steam required per pound m.e.p. would be as

$$\frac{0.2044}{37.322} \text{ to } \frac{0.2577}{52.967}, \text{ or as } 1.1256 \text{ to } 1.$$

For comparison of cost, it may be assumed that in each instance steam is generated from a feed-water temperature of 200 deg. F. A pound (wt.) of steam at 90 lb. per sq.in. absolute contains 1184.4 B.t.u. above 32 deg. F., hence each pound raised from feed water at 200 deg. F. would require

$$1184.4 - (200 - 32) = 1016.4 \text{ B.t.u.}$$

while a pound (wt.) of steam at 115 lb. per sq.in. absolute contains 1188.8 B.t.u. above 32 deg. F., and each pound raised from the same temperature of feed water would require

$$1188.8 - (200 - 32) = 1020.8 \text{ B.t.u.}$$

Therefore, the cost of steam required per lb. m.e.p. or per hp., employing 75 lb. boiler pressure, would be to the cost employing steam at 100 lb. boiler pressure as

$$1.1256 \times 1016.4 \text{ to } 1 \times 1020.8, \text{ or as } 1.1207 \text{ to } 1.$$

Action of Bourdon Gage Tube—What causes the tube of an ordinary Bourdon spring pressure gage to become straighter for an increase of pressure?

J. R.

As the tube is curved and flattened at right angles to the plane of curvature, when inflated there is a tendency for it to assume a circular form of cross-section, giving rise to tensile stress in the tube material which forms the outside of the curve and compressive stress in the material forming the inside of the curve.

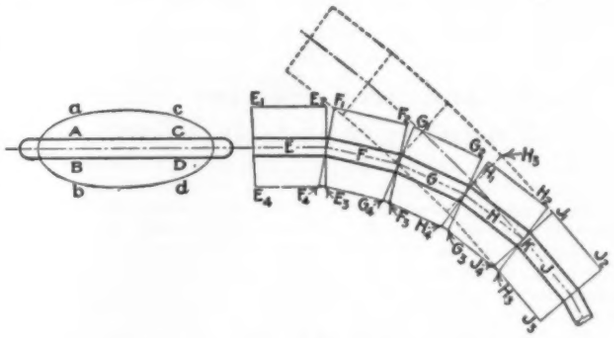


DIAGRAM ILLUSTRATING ACTION OF GAGE TUBE

The action is the same as though the curved tube was composed, as shown in the figure, of a number of straight tubes of cross-section like ACDB joined together in polygonal form EFGHJ. Such sections, when independently inflated to the oval form of cross-section acdb, would be represented by the trapezoids $E_1E_2E_3E_4$, $F_1F_2F_3F_4$, etc. But, as shown by the figure, when the sections are thus separately inflated, they would separate along the outer, or convex, side as at H_2KJ_1 and would be compressed together along the inner, or concave, side of the tube as indicated by the overlapping J_4KH_3. Hence, after inflation of the sections, when a section like H remains continuous with an adjacent section like J, the latter being held stationary, then for H_2 to remain in contact with J_1 and for H_3 to remain at J_4, the inflated section H would have to assume the position $H_3J_1J_4$. Like movement of the consecutive sections would result in a change in their alignment to that indicated by the dotted lines, and the action of straightening out from inflation would be similar if the original sections were short enough to form a continuous curve of flattened tubing, such as used in the Bourdon spring pressure gage.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Testing Central-Station Heating Mains

During the last heating season, engineers of the Merchants' Heat & Light Co., Indianapolis, Ind., have been making tests to determine whether any part of the central hot-water heating system in that city needed renewal. The tests were also designed to discover the location of any overloaded section of the piping system. The procedure of the tests was as follows: Observers were stationed at the plant, at the end of the main trunk line about 800 ft. from the plant, and at the end of laterals about 3000 ft. from the trunk line. With these watchers in readiness and with constant pressure maintained on the system, the fires under the circulating boilers were dropped simultaneously at a prearranged time. Immediately afterward the fires were forced skillfully to bring the water temperature back to normal. The various observers took simultaneous time and temperature readings, noted the fall in temperature as the cooler water passed their respective stations and also the time that elapsed before the temperature was restored to normal. With these data and with the distance between stations known, a few simple calculations gave the speed of the water in the mains and the line losses in deg. F. occurring between the power plant and the point of reading. The results were plotted with time as ordinates and temperature as abscissas. The curve produced clearly showed the passage of the cooler water by a dip in an otherwise comparatively straight line. Near the station the readings showed the dip to be very pronounced. Further out on the system it became more shallow. These dips gave an indication of the relative line losses in the main and laterals, while the velocity of the water was taken as the most definite indication of the loaded conditions of the pipe, high velocity indicating heavy loading, low velocity, light loading. Considering velocities of 4 ft. per sec. in mains and 3 ft. per sec. in laterals as the maxima allowable, the test data show conclusively that almost the entire system is in good operating condition, although the lines were laid fourteen years ago, and according to some theories of depreciation, should now be ready for replacement.

Readings were also taken on all lines to determine the difference between the flow and the return pressure. These data will be of value in considering future loading of the lines, because in general customers should not be added to a line with a differential pressure of less than 1 lb. per sq.in.—"Electrical World."

Encouraging Water-Power Development in Washington

Through its Extension Division, the University of Washington, Seattle, has adopted an interesting plan to encourage the active development of local water power, affording free expert advice for proper and effective installations at available properties. In this, the primary purpose is to assist individual owners of water sites who might be unable at the moment to employ experienced engineering talent, as well as small rural communities similarly situated, inspiring active interest in the possibilities presented.

The inauguration of this department has led to considerable activity along coöperative lines. Owners have been supplied with information applicable to service, in a consistent, economical and profitable way. In some cases recommendations to employ consulting engineers have been made, it being the particular province of the university to suggest the most feasible plan, with all essential data, rather than carry the proposed project to completion.

In explanation of this new public consulting department, the university calls to notice that hundreds of small water powers are still undeveloped in the state. Many farms and country homes are so situated that electric power for lighting and cooking could be secured at a very reasonable cost, while in some cases, heating by electricity is possible at an economical figure. Investigations show that a large proportion of the small water powers are worthy of the utmost development. Owners do not always know the value of their sites and on such uncertainty cannot afford to employ an engineer capable of giving the necessary advice; on the other hand the engineer cannot afford to give his services free.

As regards the working of the plan, the University of Washington, being a state institution, is in a position to lend assistance by sending an expert to report on the advisability of development. If no extended surveys are required, this engineer will suggest a proper method of procedure and probably make some little sketch to be followed in the construction. Should surveys be necessary and the expense is justified, it will be so reported and the owner asked to secure some private engineer to make them, provided the owner wishes it done at his expense. No charge is made for the information or technical advice given out by the university engineer, excepting his necessary traveling expenses, which must be borne by the person asking his services.

Convention of American Boiler Manufacturers

The twenty-seventh annual convention of the American Boiler Manufacturers' Association, held at the Hotel Lawrence, Erie, Penn., was called to order by the president, W. C. Connelly, on June 21, with 108 manufacturers' representatives present. The report of the committee on uniform boiler laws recited the efforts which had culminated in the A. S. M. E. code. Thomas E. Durban, chairman of the committee, said that the industrial commissions of Pennsylvania and Wisconsin had already adopted the code. He was assured that California, Chicago and St. Louis would adopt, and that the conservative Master Boiler Builders' Association had already approved the code. N. A. Baumhart, chairman of the Ohio Board of Boiler Rules, told the convention that the Ohio rules would be amended to include the A. S. M. E. code. John A. Stevens, chairman of the A. S. M. E. committee that formulated the code, urged its promulgation on behalf of the consulting engineer.

C. H. Wirmel, formerly head of the Ohio Boiler Inspection Department and chairman of the N. A. S. E. committee on legislation, invited the attendance of those interested in the general adoption of the code at the N. A. S. E. convention to be held at Columbus, Ohio, in September. John T. McCabe, boiler inspector of Detroit, approved the code, but held that the city or state could only prescribe absolute essentials, and even then the burden of proof rests on the inspector. He also announced that he would pass A. S. M. E. boilers wherever made. Dr. C. L. Huston stated that "two dollars per ton" was not the only difference between furnace and flange steel. The firebox plates, which are stressed by unequal temperatures, required more rigid inspection. The steel used should be openhearth selected from the middle of the run, and there should be closer supervision of the entire process. Mr. Lynch, representing the Association of Steel Manufacturers, testified to its approval of the code, which was a credit to Messrs. Stevens and Durban. H. P. Goodling, speaking for the portable-engine interests, said the principal objections to the enforcement of the code would be the inspection and license requirements. The attempt to adopt such measures in Florida had been frustrated because the small operators were afraid they would have to employ licensed men. Michael Fogarty, a delegate to the New York Constitutional Convention, said that a boiler law must be passed before the code could be adopted. At his request the convention adopted a resolution indorsing a proposed constitutional amendment. A copy of the resolution was sent to the Hon. Herbert Parsons, chairman of the committee on industrial relations of the New York Constitutional Convention. T. W. Herendeen, secretary of the National Boiler and Radiator Manufacturers' Association, expressed his association's approval of the code and pledged coöperation in securing its general adoption. G. S. Barnum, of the Bigelow Boiler Works, told of a rumor that a law or rule might be passed admitting code boilers to Massachusetts. T. M. Rees, of Pittsburgh, belatedly protested against the adoption of the code. He especially objected to its condemnation of lever safety valves and lap joints, quoting "Power" to show butt-strap joints were not immune from cracks. The convention voted to refer his objections to the committee on A. S. M. E. boiler code. C. V. Kellogg, president of the National Tubular Boiler Makers' Association, told of its activities and expressed sympathy with the A. S. M. E.'s efforts to promulgate the boiler code.

President Connelly recommended for consideration: The adoption of uniform specifications covering material guarantees, workmanship and methods of payment; ways and means to secure universal adoption of the A. S. M. E. code; the securing of laws whereby boilers approved by authorities in one state should be recognized as good in all states; the action of water-tube boiler manufacturers in guaranteeing boilers for 200-per cent. capacity, thus cutting the market for boilers in half.

The convention decided to form an administrative council consisting of one member each from the American Boiler Manufacturers' Association and from other allied organizations. This council will conduct a campaign for the adoption of the boiler code, the campaign expenses to be prorated among the interests represented, to the amount of $12,000 a

year. A model inspection and license law was referred to this council to be modified and adapted to conditions in various parts of the country. H. D. Mackinnon presented a report of the committee on uniform cost system. The convention adopted suitable resolutions on the deaths of Past-President E. D. Meier and Past-Treasurer Joseph F. Wrangler. The following officers were elected: President, W. C. Connelly (reëlected); first vice-president, C. V. Kellogg; second vice-president, G. F. Barnum; third vice-president, E. C. Fisher; fourth vice-president, Isaac Harter, Jr.; fifth vice-president, Charles F. Hooper; secretary, J. D. Farasey; treasurer, H. N. Covell; representative on administrative council, E. R. Fish. Past-Presidents Richard Hammond and Henry J. Hartley were elected honorary members. Fifteen firms joined the association during the past year, making 87 companies and 15 associate members enrolled. Six of the fifty charter members were present at the convention. The convention passed a vote thanking the Erie City Iron Works, Union Iron Works, Burke Electric Co., and the visitors that had contributed to the discussion and the committee work. The business sessions concluded with a banquet at the Hotel Lawrence on the evening of June 22.

Future Developments in Heating and Ventilation*

By A. H. Barker

SYNOPSIS—The author discusses the general nature of unsolved heating and ventilation problems and outlines some interesting experimental work now being conducted at the University College.

The twin sciences of heating and ventilating have more unexplored problems and greater difficulties attending their solution than almost any other branch of engineering. This is due to the immense complexity of the two sciences, the difficulty of defining in exact terms the results to be expected and the fact that the criterion of success has of necessity been the feelings of individuals rather than the readings of scientific instruments. In addition, the immense power of adaptability of the human organism tends to make actual variations of conditions appear unimportant in practice. In this branch the first obstacle is the great difficulty of finding the facts.

Consider, for instance, the first problem for an engineer endeavoring, without previous experience, to arrange a satisfactory scheme for ventilating a building. He would begin with the assumption that the artificial ventilation of a building consists of forcing in a calculated volume of air. If he were familiar with fans and the laws of the flow of air in ducts, he might think the task easily accomplished. But after he had once tried to satisfy the occupants of the building, he would find the distribution of air currents a problem of great difficulty even in a small building. Although each of these currents obeys rigidly accurate laws of nature, as a whole they are so complex that their expression as terms of exact science is almost impossible. Complaints of the ventilation of almost every public room are heard, but should the ventilating engineer be held responsible when no one can specify what is wrong or what is needed to put it right?

The arrangement of a satisfactory heating system is no less complex. Heat is delivered into the room by convection currents of heated air and by radiant energy. These forms of heat are quite different from each other, yet they can be instantaneously transformed from one to the other and back again. Their measurement, again, is not a problem to be easily solved. The mere act of measuring the amount of radiant energy turns all or part of it into convected heat.

The most baffling difficulty, however, in the attempt to reduce this subject to an ordered science is that the object of both heating and ventilating, though primarily physiological, is also to some extent psychological. The primary object is to keep the inhabited rooms healthful; to keep them comfortable is of almost equal importance. The effect of any given condition on the human body is, if possible, more complicated than the laws which govern air currents and heat flow. The author believes that in the interests of health the temperature maintained should be as low as can be endured without real discomfort. Yet others will say that the room should be so warm that the occupants feel comfortable without any effort. No one can tell us within 300 per cent. how much fresh air per head per hour is the minimum consistent with health. A room filled with air absolutely pure, so far as chemical analysis can detect, may feel very stuffy. For instance, in the House of Commons the air is, chemically speaking, as pure as in any room in the world. No less than 13,000 cu.ft. of air is supplied per head per hour, yet it produces the effects associated with defective ventilation—lassitude, sleepiness, and infection. A room may, on the contrary, feel fresh and sweet when, judged by chemical standards, the air is very bad. The author has analyzed air containing 25 volumes per 10,000 of CO_2, which felt as fresh as a spring morning, although 10 volumes is regarded as the extreme allowable impurity.

The future of heating and ventilating depends, on the scientific side, upon the further analysis of the conditions that produce the feeling of comfort and other effects. This half of the problem is for the psychologist. The attempt to specify healthful and comfortable conditions involves experiments, that in essence are attempts to calibrate human beings.

The practical side of the problem depends on the controlling of these conditions and on the further development of construction and transmission apparatus. We must first be able to express exactly each of the chemical and physical conditions which make up the sum total of the room condition. The criterion of successful design must not be the self-contradictory feeling of people, but must be the exact reading of radiometers, hygrometers, airmeters, apparatus for the analysis of air, dust counters, thermometers and other instruments.

The practical problem is to introduce heat in quantity and form to make the building comfortable. As heat can be introduced by convection currents and by radiation, there will be at least two corresponding temperature conditions in a room. The expression "temperature of a room" commonly means the reading of a correct thermometer in the room. This thermometer does not indicate the temperature of the surrounding air, for it is largely influenced by the amount of radiant energy impinging on the bulb and having no connection with the air temperature. The problem is not solved when the heat causes a thermometer in a room to read a certain figure. Of course, in designing a large system a great deal of calculation is required to obtain a uniform and proportional flow to all parts of the apparatus. Even when this is done a large number of persons undoubtedly cannot endure apparatus heat in any shape.

To get to the bottom of the problem the temperature of the air itself and the temperature corresponding to the radiant conditions should be studied. To make a systematic beginning we must also develop experimental means for recognizing and measuring air and radiant temperatures, and quantities of convected heat and radiant energy. It is necessary to determine experimentally the relation between the thermometer rating, the air temperature and the radiant temperature. The term "radiant temperature" signifies the temperature registered by a thermometer if there were no air in the room at all—a sort of mean of the temperature of the surrounding walls.

Separate instruments have been devised at the University College for registering the air and radiant temperatures. The first shows the mean temperature of all exposed surfaces, such as the walls of the room and the furniture, affecting the bulb of the thermometer. The principle of the instrument is to surround a delicate thermometer with air at the same temperature as that of the room, and also to envelop it with a surface whose temperature can be adjusted to any degree and held absolutely uniform. The instrument for finding the temperature of air is constructed on the principle that a thermometer surrounded both by air and by double-walled surfaces at the same temperature as the air in the room will read exactly the temperature of the room air. If the radiant and air temperatures are made identical, both will be the same as the thermometer reading.

*From a paper read before the Society of Engineers (Inc.), in England, and abstracted in "The Mechanical Engineer."

The author claims to have proved with these instruments that the stuffy feeling often associated with heating systems is caused largely by too high air, and too low radiant temperatures. The freshness of a building depends on keeping the air temperature relatively low and the radiant temperature high. This explains why a room warmed by an open fire often feels much more comfortable than one heated by a radiator. The temperature and humidity of the air are the important points, and not its chemical freshness, freedom from CO_2 or from other organic products.

In this connection it is important to separate the heat communicated to a room as radiant energy from that communicated by warming the air. In an apparatus contrived for this purpose, a canopy collects all the warm convection currents proceeding from the heater. A delicate electrical method is applied for testing the quantity and temperature of the heat. The heater is surrounded by radiant-heat meters, such as radiometers and thermopiles.

The effect on the human organism of dust in the air must be determined, but as there are millions of particles per cubic inch, special methods are required for counting them. In the "Aitken" dust counter a minute sample is measured and diluted largely with a known quantity of pure and dustless air. The particles of dust in a fraction of this enlarged volume are deposited on a glass plate underneath a microscope and actually counted. By multiplying by the total number in a cubic inch, the original sample can be calculated.

In no respect has the science of heating and ventilation been more backward than in the knowledge of laws governing the movements of air. The flow of air is brought about by the operation of very trifling momentary and constantly varying causes. So, no doubt, is the flow of electricity in relatively large quantities at low voltages. The ventilating engineer is also concerned with a comparatively large flow of air at low differences of potential. The electrician would find difficulty in investigating the current through a cube of copper measuring three feet in every direction. Local circuits would be set up by any accidental distribution of electromotive force, such as those set up by the movements of a magnet in the neighborhood. This exactly corresponds to the problem with which the engineer is confronted in ventilating a building. Air is introduced, for instance, into a room at a certain point. At other points in the room, sometimes near, sometimes remote, from the point at which the air is introduced, currents of air which the occupants of the room call "drafts," are experienced. It is held up as a reproach to the ventilating engineer that these exist, and so no doubt it is. Yet the laws of pneumatics are quite as definite as those of electricity. The difficulty is in gaging and controlling the working conditions. In developing experimentally the laws of pneumatics on a basis somewhat similar to those of electricity, standard units must be evolved comparable with those of electrical science.

We are experimentally testing the validity in all kinds of pneumatic flow of a fundamental formula similar to Ohm's law. The law may be stated as $H = RQ^2$. The unit of aëromotive force H is naturally a foot of air column, or that difference of pneumatic pressure against which it would require one foot-pound of work to force one pound of air. The unit of flow Q is one cubic foot of air per second. Since the corresponding unit of resistance is closely equal to the resistance of a hole 6 in. diameter in a thin flat plate, a pressure equal to one foot of air column will cause a flow of one cubic foot per second through the hole. If we can compare all pneumatic resistances with this unit, we will understand the flow of air better than when working with the present complicated formulas. The fundamental difference between the laws of pneumatic and of electrical flow is that in the former the aëromotive force is nearly proportional to the square of the flow, whereas with electricity the electromotive force is exactly proportional to its first power. These differences are not sufficient to exclude the application of similar experimental methods. A large apparatus, the pneumatic analogue of the Wheatstone bridge, is used for the determination of pneumatic resistances, and sundry methods of battery resistance have been applied to determine the internal resistance of a fan. If we can specify the proper resistance in pneumatic units for a boiler flue and chimney, we can deal rationally with the much vexed chimney problem. This problem has been treated only in the most incomplete and perfunctory manner. We can determine, by the application of these rules, the actual resistance of a boiler flue, and can tell exactly the maximum capacity of a plant in heat units or in pounds of steam, even without lighting the fire in the boiler. To thus determine the resistance of boiler flues and chimney shaft, it is only necessary to have a fan discharge to the boiler through a chamber in which a constant low pressure of air can be maintained. The resistance between the fan and the boiler inlet is then varied, the current measured, and the pneumatic resistance can be at once established.

It is easy to show that the total resistance of a boiler plant consisting of three Lancashire boilers, 28 ft. by 7 ft. 6 in., with a chimney 100 ft. tall, should be about 0.00172 unit of resistance. It is even possible to determine this resistance without a fan or an anemometer, but with a very accurate micrometer pressure gage. By measuring accurately the pressure in the inlet chambers due to the pull of the chimney, the flow of air through the flues at any given moment can be determined by calculation. The resistance of the boiler flues and chimney in pneumatic units can then be easily found.

Enough has been said to show engineers that there is more in this subject than the collection of rough rules of thumb found in the current literature. At present, heating and ventilation resemble mechanical science at the time of Newton, or electrical science at the time of Faraday. It would be very much to the advantage of mankind if engineers would take more seriously a subject worthy of a high place in practical science.

Results of the Locomotive Boiler Inspection Law*

By Frank McManamy†

The following table shows the inspection work performed each year since the passage of the law three years and eight months ago, and the decrease in the percentage of locomotives reported defective indicates in a measure the improvement in conditions:

	1914	1913	1912
Number of locomotives inspected.....	92,716	90,346	74,234
Number found defective.....	49,137	54,522	48,768
Percentage found defective.....	52.9	60.3	65.7
Number ordered out of service.....	3,365	4,676	3,377

It does not, however, fully show the improved conditions resulting from the operation of the law, because, as pointed out in our 1913 report, attention was first concentrated on the more serious defects, so that the number of fatalities might be reduced; therefore, the improvement is more accurately indicated by the reduction in the number of casualties, as shown by the following table:

	1914	1913	1912
Number of accidents.....	555	820	856
Decrease from previous year, per cent...	32.3	4.2	...
Decrease from 1912, per cent.....	35.1	...	...
Number killed	23	36	91
Decrease from previous year, per cent...	36.1	60.4	...
Decrease from 1912, per cent.....	74.7	...	...
Number injured	614	911	1005
Decrease from previous year, per cent...	32.6	9.3	...
Decrease from 1912, per cent.....	38.9	...	...

The data cited are taken from the records up to July 1, 1914. A check of the first six months of the present year, that is, from July 1, 1914, to Jan. 1, 1915, in comparison with the corresponding period in the preceding years, shows the following results:

During the period ended Jan. 1, 1914, there was a total of 349 accidents that resulted in injury, with 15 killed and 385 injured thereby. During the period ended Jan. 1, 1915, there was a total of 253 accidents that resulted in injury, with 6 killed and 271 injured thereby, or a decrease of 27.5 per cent. in the number of accidents, 60 per cent. in the number of killed and 30 per cent. in the number injured by the failure of locomotive boilers and their appurtenances.

*From a paper before the Western Railway Club, Chicago.

†Chief, boiler inspection department, Interstate Commerce Commission.

Going back further and making a comparison with the corresponding period for 1912, we find that during the six months period ended Jan. 1, 1913, there were 470 accidents that resulted in injury, with 24 killed and 512 injured thereby. In other words, the number killed by failure of locomotive boilers and their appurtenances during the first half of our fiscal year beginning on July 1, 1912, was 12½ per cent. greater than for the corresponding periods in the two following fiscal years, with almost as great a decrease in the number injured and the number of accidents. Or, to state the whole matter briefly, in three years the number killed by failure of locomotive boilers and their appurtenances has been reduced from about 100 per annum to less than one-fourth that number, and the number injured from more than 1000 per annum to less than one-half that number, with a corresponding decrease in the number of accidents.

WHY LAW HAS REDUCED BOILER ACCIDENTS

These are the direct results of the operation of the Locomotive Boiler Inspection law and indicate the manner in which it is fulfilling the purpose for which it was enacted—to promote safety. The question will no doubt arise as to just what the law has done to produce such results; and in reply I will say that they are due to a number of reasons, among which are more careful inspection, more prompt repairs and attention to minor defects, investigation and classification of every accident that resulted in injury, with a view to determining the cause and remedying it, and giving publicity to the information collected.

FEDERAL INSPECTION PROMOTES BETTER MAINTENANCE OF BOILERS

No railroad man with a trace of honesty and a knowledge of conditions and practices prior to the passage of the law can question the fact that, generally speaking, inspections are now more carefully and more regularly, and repairs more promptly, made, and that the question of repairs is less apt to be determined by the number of loads in the yard awaiting movement, although unfortunately that is still occasionally considered to be the deciding factor; an illustration being a recent request by a master mechanic to operate a locomotive with 43 broken stay-bolts a distance of 312 miles, because they needed the power.

FIREBOX STUDS NEGLECTED

The importance of giving attention to minor defects can be shown by an illustration: During the last fiscal year 18 persons were injured from studs blowing out of firebox or wrapper sheets. In almost every instance they gave warning of their defective condition by leaking before they blew out; and they can be renewed with less expense to the company at that time than after they blow out and cause injury. It should be done, and the practice of repairing leaking studs by calking, or permitting them to continue in service without repairs, should be discontinued.

Investigating every accident to determine the cause, and classifying it so that the number and causes of the various accidents can be readily seen, has been an important factor in shortening the accident list. This information is given publicity in our annual report for the purpose of directing attention to the causes of accidents so that they may be avoided.

FEWER CROWN-SHEET FAILURES

I have recently had occasion to read carefully statements made before Congressional committees at the time the boiler-inspection law was pending, to the effect that all boiler explosions were really crown-sheet failures due to low water, therefore were man failures which could not be prevented by Federal supervision; and still more recently have listened to a repetition of these statements from a source which would indicate that they represented the consensus of opinion of railroad officials. To correct this misapprehension, attention is directed to the records of such accidents since July 1, 1911.

During the year 1914, as compared with 1912, accidents which are usually termed boiler explosions which resulted in injury have decreased 44 per cent. or from 97 in 1912 to 54 in 1914, and the number of killed and injured has decreased 64 per cent., or from 290 to 104. During the same period crown-sheet faiures due to low water decreased 48 per cent., or from 92 to 48.

I am directing attention especially to this class of accidents, first to show that such casualties as these, which were said to be unpreventable, have been materially reduced, and also because our investigations have shown that by proper application and maintenance of boiler appurtenances they can be still further reduced. I refer to the location, manner of application and maintenance of such appurtenances as injectors, gage-cocks and water glasses.

INCONVENIENT LOCATIONS OF GAGE GLASSES A MENACE

Rule 42 provides that "every boiler shall be equipped with at least one water glass and three gage-cocks. The lowest gage-cocks and the lowest reading of the water glass shall be not less than 3 in. above the highest point of the crown-sheet." While it may be a compliance with the letter of the law to locate these appurtenances where they can be most easily applied, regardless of their convenience to the enginemen, it is manifestly not a compliance with the intent of the law and is not conducive to safety, as an improper or inconvenient location may seriously interfere with their proper use. As an illustration of an improper location, a certain type of locomotive has the water glass directly behind the engineer and out of sight of the fireman. As these locomotives are used in passenger service on a busy division, where it is at times necessary for the engineer to read a signal each 20 sec. or less, it is certain that under such conditions the reading of the water glass will not be as frequent as it would if placed in a more convenient location.

In other instances glasses are found so obscured by other boiler appurtenances or by improper shields that it is difficult, and under certain conditions impossible, to see the water level. A recent investigation of a crown-sheet failure showed that the cab arrangement was such that the water glass and gage-cocks were 9 in. above the engineer's head and that he regularly carried a small keg to climb upon to try the gage-cocks. Can it be seriously questioned that such conditions cause accidents, particularly when operating in a busy terminal?

Using a shield that obstructs the view of the water glass is also too common. In some instances it has been found that the shield almost entirely obscures the water glass. On deckless locomotives we frequently find the water glass located behind the wind sheet or back wall of the cab, in such a position that only by leaving his usual position and peering intently into the space between the boiler head and wind sheet can the engineer see the water level. On the same type of locomotives we find gage-cocks so located that to try them the enginer must step back out of reach of the throttle, brake valve and reverse lever. The inevitable result is that when busy switching, or when trying to get a tonnage train over a hill on a slippery rail, gage-cocks located out of reach are not used as often as they otherwise would be.

VITAL IMPORTANCE OF CORRECT LOCATION OF BOTTOM GAGE-GLASS FITTING

The manner of application is also important, both as to water glasses and gage-cocks; and in reference to this I will quote a paragraph from a paper I read before this club in 1913:

> Another matter that has not always received the consideration that it should is the location of the bottom water-glass fitting. The opening of the boiler for this fitting should always be above the highest point of the crown-sheet, yet on a large percentage of locomotives they appear to have been located without much regard to the height of the crown-sheet, the proper height of the lowest reading of the glass being obtained by the use of nipples of various lengths. When this opening to the boiler is made below the highest point of the crown-sheet, if the top water-glass cock is closed or the opening restricted, water will show in the glass when there is none on the crown-sheet, and we have records which show that this has been the cause of more than one crown-sheet failure; therefore, I desire to urge the importance not only of having the fitting so applied that the glass cannot under any circumstances show water when the crown is bare, and this means that the fitting should be so designed and located that the proper reading of the glass can be obtained and the opening to the boiler kept above the crown-sheet.

I am referring to this again for the reason that investigations conducted since that time have shown positively that the combination of conditions shown in that paragraph is one cause of crown-sheet failures, one of which occurred quite recently.

GAGE-COCKS AND THEIR DRIPPERS

We also find that the manner in which gage-cocks and gage-cock drippers are applied indicates that the purpose for which they were applied did not receive sufficient consideration. While the application of a dripper is important to prevent the discharge from the gage-cocks scalding anyone in the cab, it should not be so close to the cocks that the nipples extend down into the dripper, preventing enginemen from seeing the discharge, as dripper pipes occasionally become obstructed and fill with water, in which event the sound of water and steam are identical.

This is not offered as an excuse for crown-sheet failures due to low water, because we believe there are no excuses; but our investigations have shown that these conditions are sometimes the cause of such accidents; therefore, sufficient care and foresight should be exercised to so apply all these appurtenances that they will to the best advantage serve the purpose for which they are required.

FREQUENT FAILURES OF INJECTOR STEAM PIPES

Failure of injector steam pipes continues to be one of the most frequent causes of serious accidents, and is the only one which shows an increase during the present fiscal year over the corresponding period for the previous year.

Of 16 injector steam-pipe failures five were due to nuts breaking, one to threads stripping, one to a nut being too large, five to collar or sleeve breaking and four to defective brazing. Each of the accidents due to the nut breaking or stripping resulted from attempting to tighten the joint without shutting off the pressure, for which the remedy is obvious, although perhaps somewhat difficult to apply.

BRAZED JOINTS DANGEROUS UNLESS REINFORCED

The other nine failures, four of which were due to poor brazing and five to collar or sleeve breaking, could, I believe, have been prevented by extending the pipe through the collar or sleeve and flanging or beading it, thus reinforcing the collar and reducing the strain on it, as the end of the pipe itself will be solidly held in the joint; therefore, it will carry the load. If properly applied in this way, brazing is not necessary, although it can be done if desired. This method of application is at least as cheap as brazing, and defective or improper workmanship can be discovered by inspection, which is impossible with the brazed connection.

The discussion on the location of the bottom fittings of gage-glasses was to the effect that that fitting should always be placed above the highest point of the crown-sheet, notwithstanding the complaint of some engineers that such location prevents a timely warning of foaming.

Fuel-Oil for Locomotive Use*

From 1907 to 1914 the use of fuel oil by railroads increased 112 per cent., until a total of 31,000 miles, distributed over 50 railways, was operated with this fuel. For a time during the years 1912 and 1913 there appeared to be a tendency to discontinue the use of oil, on account of the great demand for the distilled products of crude oil used for other purposes, leaving a diminished supply of fuel oil and residuum. Opening up of new fields, more efficient methods of distillation, the production of gasoline from natural gas, etc., have again increased the fuel oil supply, and its use is again extending.

In the combustion of fuel oil, where a steam spray is used for vaporization, we are confronted with the fact that in the process of atomization the particles of oil are started on their way to the flues even before they are partly burned. The first result of these particles coming into the heated portion of the furnace is to separate the carbon from the hydrogen, the former thus being left as a fine dust floating in the furnace in such a manner as to be easily carried to the flues unconsumed, to be deposited as an insulating layer of soot, or to be carried out of the stack in the form of black smoke. If these fine particles of carbon were attached, as in a bed of coals, a supply of air could easily complete their combustion. With liquid fuel, therefore, the diffusion must be simultaneous with ignition, with the resultant long flame. The surface tension of oil, especially when the particles are finely divided, is such as to make the drops assume a spherical form of extreme rigidity and therefore expose the least possible area to the oxygen. We are thus brought to realize that large furnace volume is essential to the burning of fuel oil. While the relative dimensions are of minor import to the volume, it is evident that a flame passage of sufficient length to prevent unconsumed particles passing to the flues must be provided. It was the realization of the limited volume of the locomotive furnace that brought about the change from back- to front-end burner arrangement a few years ago, in an attempt to lengthen the flame path.

While it is generally conceded that lack of oxygen is responsible for smoke, the restricted furnace volume and the attending lack of time for the proper mixture of the gases in the more highly heated portion of the furnace is the most common cause for black smoke from an oil-burning locomotive. One of the difficulties met with in the use of oil in the locomotive is the frequent necessity for the removal of soot from the flues, by means of sanding out. This, of course, is attended with several disadvantages, not the least of which is the resultant loss of fuel.

Special attention is brought to this point in connection with locomotive oil-burner furnace design because of the general tendency to restrict the furnace volume by carrying draft pan and brickwork too high in the firebox, covering up valuable heating surface and bringing about the continual necessity for forcing the fire at the expense of the remaining exposed surfaces.

*Abstract of paper read by G. M. Bean before the International Railway Fuel Association, Chicago, May 17-20, 1915.

One of the principal requirements in the burning of oil is to expose the fuel to the furnace heat so that the greatest possible area is presented to the oxygen. A study of the atomization of oil is therefore of some importance, and it will be readily seen that the stretching of the surface of fuel oil is a study of capillary action and that it is not hard to determine the work necessary. Oil in bulk has little surface, but when broken up into fine particles it has the combined surface of the spherical areas of the drops thus formed, and the work of atomization is the work of stretching the surface of exposure.

Theoretically, it should be possible to atomize oil to a definite fineness of spray by means of a mechanical device much more economically than by means of the steam jet.

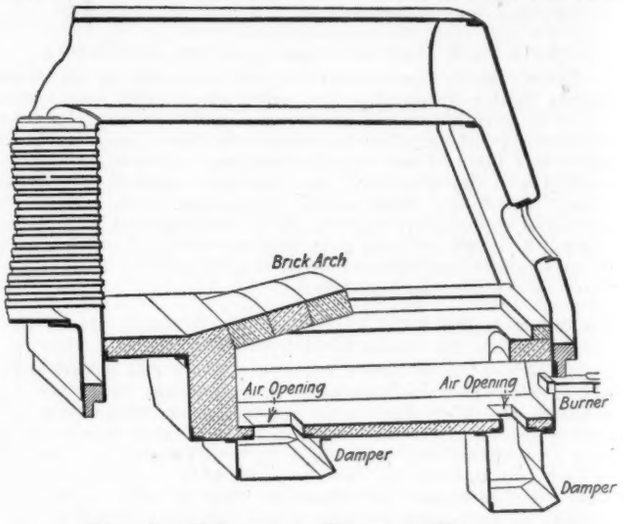


FIG. 1. BURNER AT BACK OF FURNACE

Many attempts have been made along this line, with almost as many failures. The simplicity and flexibility of the steam-jet burner make that method difficult to improve, and the fact that the type of burner now in use on the majority of locomotives is practically the same as the one first introduced in this country would lead to the belief that when improvement is made in the oil-burning locomotive furnace, it will not be made in the burner. One of the simplest of all burners and now standard on the Santa Fé Ry. has been in continuous use on that line since oil was first introduced as fuel, and has never failed, in itself, to show up well in connection with any furnace design. In other words, where failures in design or arrangement were met with, it was always traced to other features being wrong, rather than the burner. The type of burner therefore seems of minor importance, so long as it is simple, substantial, not easily stopped up and easily cleaned.

Locomotive furnaces are not considered ideal for the use of fuel oil, and for this reason as much as any other there have been as many different furnace arrangements as there have been localities in which oil fuel has been used.

At the first inception of the idea in this country it was natural that the designs used in Russia should be followed. The burner was placed under the rear of the firebox, Fig. 1, and directed forward with an upward incline, so that the flame shot under a low, short brick arch, with the result that combustion became so intense in this limited space as to cause the flame to pass from under the arch with such velocity as to impinge on the door-sheet, side-sheets and crown-sheet, with detrimental results. Bad water conditions throughout the Southwest aggravated this to such an extent that the life of fireboxes was only about eighteen months or two years, and the replacing of them soon became a severe burden. The back-end burner arrangement also required an excessive quantity of firebrick, which not only gave trouble by continually burning out, but also served to cover up valuable heating surface, restrict the furnace volume and throw an increased load on the remaining heating surface.

While the back-end burner arrangement is still in use to some extent throughout Texas, it has entirely disappeared from every other section. The burner is now placed in the front end of the draft pan, Fig. 2, and directed toward the rear in such a manner that the draft is forced to reverse the direction of the flame before it passes to the flues. The furnace is open, the brickwork is kept low and the maximum of heating surface is exposed. The correct drafting of this arrangement is still a somewhat debatable subject, but the general idea seems to favor the admission of the principal volume of air through openings in the vicinity of the flash-

wall, which is built up under the door, it being the plan to admit this air through numerous small openings, preferably circular in shape and distributed well over the rear third of the draft pan in such a manner that the air is brought in contact with the flame from several directions and not in too concentrated a volume. A small amount is also admitted around or under the burner, so as to prevent it from overheating and to keep the flame from dragging on the floor of the pan. This arrangement results in a uniform distribution of heat and the consequent lengthened life of the fireboxes and flues, until it can safely be said that for service under like conditions, a firebox on a locomotive burning oil will last longer than one in a coal burner if consideration is given to the extra work possible to be obtained from the oil burner.

Oil requires from 20 to 30 per cent. more air per pound of fuel than the average bituminous coal. There is a tendency to restrict the air openings in draft pans of oil burners, and it is generally the rule that with locomotives of the same class in both oil- and coal-burner service, the oil burner will have the smaller nozzle, indicating the necessity for maintaining a higher front-end vacuum to draw in the necessary amount of air to make the engine steam properly. This is attended with the added difficulty that the high velocity of the entering air produces a more concentrated column or stream, which is difficult to break up, requiring a heavy atomizer, the use of which has its disadvantages.

There is a question whether the open furnace created by the front-end burner arrangement is all that can be desired, for it is true that the gases will follow the path of least resistance and the velocity at the center of the combustion space will be much higher than at the sides, this indicating the necessity of some sort of a baffle to increase the velocity of flow at the top and sides where the gases wipe the heat-absorbing firebox sheets. It is also apparent that when the flame path is surrounded by heat-absorbing surfaces to hasten the process of diffusion and shorten flame length, the subjecting of the gases to the presence of incandescent baffles is desirable.

Aside from the two furnaces outlined there is in service on one of the Southwestern railways, as well as on some Mexican railways, the arrangement shown in Fig. 3. This differs from the others in that it has a burner in both the front and the rear of the draft pan, directed toward each other, the line of flame of the front burner being slightly higher than that of

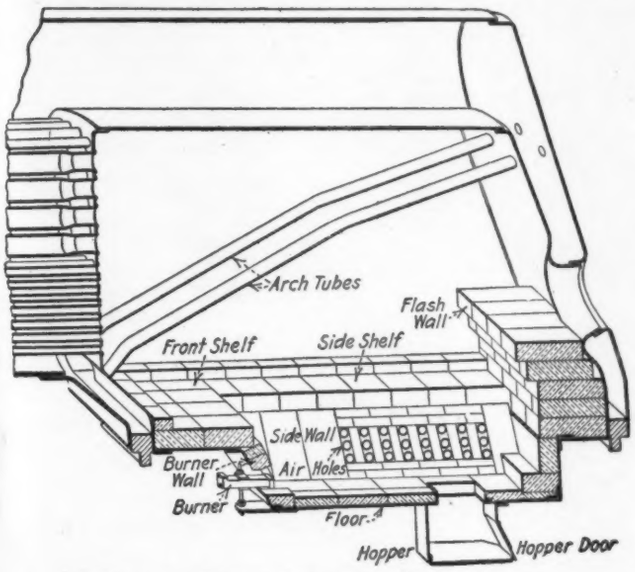


FIG. 2. FRONT-END BURNER FURNACE

the rear. This furnace also has the advantage of the low brickwork and large exposed heating surface. In fact, the opposing burners do away with the necessity for a high flash-wall under the door.

In the two last-named types it is the practice to keep the brick low on the sides and expose all possible heating surface. Firebrick for this service must be of good quality, as the firebox temperatures range from 2500 to 2750 deg. F., which, with the fluxing action of the salt and alkalies carried in the oil, are severe on the furnace and cause it to give out readily, making frequent renewals necessary. The proper maintenance of brickwork is essential to good results, and the possibility of the brickwork falling down in the path of the flame must be avoided, as it usually results in an engine failure.

The oil supply is carried in tanks built to fill the coal space of the tender and piped from there through suitable connections to the burner. It is generally necessary to provide means for heating the oil so as to insure a proper flow, as gravity is depended upon for the necessary pressure. This heating is also an aid in atomizing, and various means are provided for the purpose. The original practice was to turn steam directly into the oil, but aside from an emergency feature, this has been generally abandoned, as the accumulation of condensation gave trouble in disposal, as well as by getting into the oil line and interfering with the burner operation. The draining of the condensation from the tank was

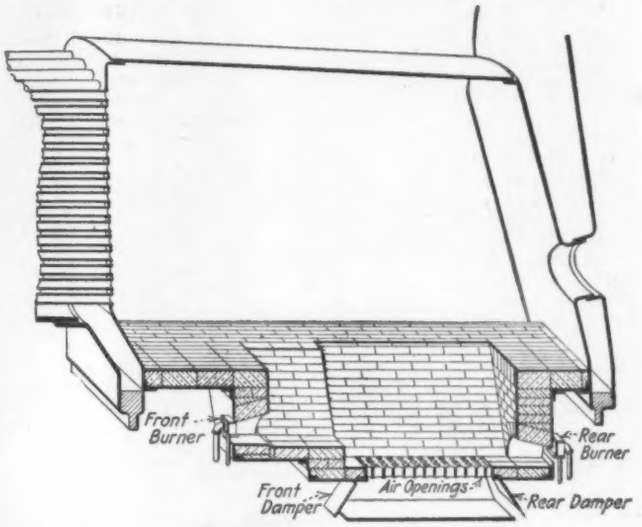


FIG. 3. BURNER AND BRICK ARRANGEMENT IN THE HAMMEL FURNACE

always accompanied by some loss of oil, and the direct heating often resulted in overheating the entire contents of the tank, with the attending loss. An improvement was to place steam coils in the space and heat indirectly. This had some advantages, but it also caused trouble by overheating and by the pipes leaking at the joints. It is probable that the box heater is the most desirable arrangement. It is indirect in its action, only heats a sufficient volume to insure a supply at the burner and is not liable to cause trouble by allowing water to get into the oil storage.

The oil-storage tanks are provided with suitable gages or measuring devices to give a check on their contents at all times. Means are also provided for cutting off the supply of oil to the burner in case of accident, such as a wreck or a break between the engine and tender. The supply of oil is regulated by means of a suitable valve placed near the burner and operated through connections by the fireman. In some climates it is necessary to provide an auxiliary heater in the pipe line to reheat the oil before it goes to the burner. Such a heater should be used only when necessary, as extensive heating tends to carbonize the fuel in the oil-supply line and the burner.

Emphasis should be placed on the fact that the oil fireman is an important factor in the success of the operation of oil-burning locomotives. He must intelligently follow every movement of the engineer that demands regulation of the fire. He has two gages to guide him—the top of the stack and the steam gage. That is, the proper steam pressure must be maintained with the least possible smoke. A thin gray color at the top of the stack is usually indicative of proper combustion.

Given a modern locomotive with a furnace designed along the lines indicated, with equipment in proper adjustment and an intelligent engine crew, the result should be of as high an order as is so far attainable with steam-operated motive power.

New York State N. A. S. E. Convention

The twentieth annual convention of the New York State Association; N. A. S. E., was held June 11 and 12 at Auburn. Upward of fifty delegates were in attendance at the business sessions, which were held in Woodmen's Hall. The first floor of this building was arranged for the use of exhibitors. The convention was called to order Friday morning by F. J DeWitt, chairman of the local committee. He introduced City-

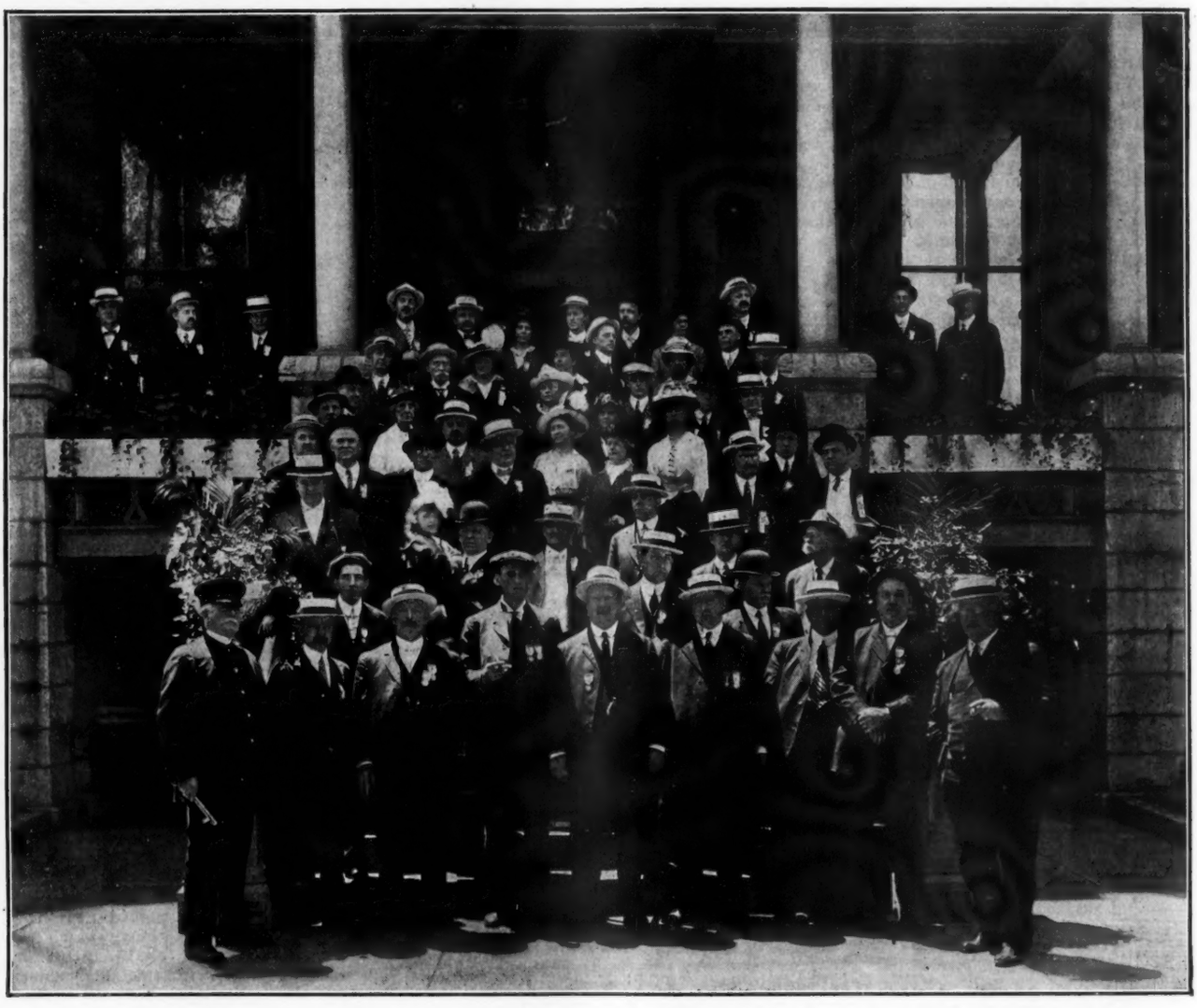
Attorney William S. Elder, who welcomed the delegates in the absence of Mayor Charles W. Brister. State-President Frederick Felderman responded to this address of welcome. The next speaker was Charles G. Adams, secretary of the Auburn Chamber of Commerce, who gave a description of the manufacturing resources of the city. National Vice-President Walter Damon, of Buffalo, dwelt briefly on the aims and principles of the association. He was followed by Past-National-President Reynolds, of New Jersey, who outlined the aims and plans of "The National Engineer." State-President Felderman then called the business meeting to order and announced the various committee appointments.

A feature of the convention was a luncheon given to the delegates and guests at the Osbourne House, through the courtesy of the McIntosh & Seymour Corporation. Afterward, special cars conveyed the party to an inspection of the company's plant. The entertainment program also included an illustrated lecture on oil and steam engines, given under the auspices of the McIntosh & Seymour Corporation; an inspection of the Auburn prison; a trip to the plant of the Empire Gas & Electric Co., and auto rides for the ladies to points of interest in the city.

A pleasant surprise to State-President Felderman was the presentation of a handsome clock. A silver service tray was given to his wife. Past-National-President Reynolds made the presentation addresses. A memorial service for members who had passed away during the past year was conducted by Vernon N. Yergin, pastor of Calvary Presbyterian Church. At the closing session Niagara Falls was chosen for the June, 1916, meeting. The state officers unanimously elected were: William H. Aydelotte, of Niagara Falls, president; William Downey, New York City, vice-president; William Roberts, Yonkers, secretary; William Downes, New York City, treasurer; Joseph C. Butrich, conductor; George Ely, doorkeeper; and David Larkin, chaplain. William Bedard was chosen to succeeded himself as state deputy.

The exhibitors were as follows:

Albany Lubricating Co.
Amer. Steam Gage & Valve Co.
Anderson Co., V. D.
Auburn Woolen Co.
Burg & Hill
Clapp Mfg. Co.
Columbian Rope Co.
Crandall Packing Co.
Cross, Orrin C.
Cuddy & Geherin
Dearborn Chemical Co.
Dunn McCarthy Co.
Eccles Co., Richard
Engineering Supply Co.
Garlock Packing Co.
Garrett Coal Co.
Henry & Allen
Herron Hardware Co.
Home Rubber Co.
International Harvester Co.
Interstate Machine Co.
Johns-Manville Co., H. W.
Keystone Lubricating Co.
Lunkenheimer Co.
McIntosh & Seymour Corp.
McLeod & Henry Co.
"National Engineer"
New Birdsall Co.
Otis Elevator Co.
Peerless Rubber Mfg. Co.
"Power"
Quaker City Rubber Co.
Roebling Sons Co., John A.
Smith & Pearson
Wadsworth, David & Son
Woodruff & Murphy.



DELEGATES TO NEW YORK STATE N. A. S. E. CONVENTION, IN FRONT OF AUBURN STATE PRISON

Co-operators

To conserve and continue the work done by Frederick W. Taylor, the initial steps have been taken to found an organization to be known as the Frederick W. Taylor Coöperators. In harmony with Mrs. Frederick W. Taylor's request, James M. Dodge, Carl G. Barth, Morris L. Cooke and H. K. Hathaway have taken the initiative and have issued a preliminary letter stating the purpose of the organization. This is to gather books, data and other material that would be of use in a biography or for a memorial to Mr. Taylor, and to provide for the continuation and extension of the Taylor System of Management.

Rear Admiral Isherwood Dead at 92

Benjamin Franklin Isherwood, engineer-in-chief of the United States Navy during the Civil War and one of the founders of the experimental theory of the steam engine, died at his late residence in New York on June 19, in his 93d year. Born Oct. 6, 1822, in New York City, he was a great-grandson of a distinguished French military engineer, Captain Du Clos, an officer on General Lafayette's staff in the American Revolution. His early schooling was received at the Albany Academy, where he studied natural philosophy under Joseph Henry, after which he entered the employ of the Utica & Schenectady R.R., and later went to work on the construction of the Croton aqueduct, on its completion entering the service of the Erie R.R.

His entry into governmental service was under the Lighthouse Board, where he seems to have performed work of responsibility, for he was sent to France to superintend the construction of some lighthouse lenses from designs by himself. The steam-engineering corps of the Navy was meanwhile being organized by Charles H. Haswell, and Isherwood was one of its earliest appointees, being made first-assistant engineer, and in 1848 was promoted to chief engineer. Meantime the Mexican War had been fought and he had been an active participant on shipboard; in fact, he was in every naval action. He served on the "Princeton," the first American screw steam vessel, and later on the "Spitfire." After the war he cruised for three years in the "San Jacinto," attached to the Asiatic squadron.

LATE REAR ADMIRAL ISHERWOOD

One of the earlier performances that brought Isherwood professionally into notice was the design of alterations for the engines of the "Allegheny," 1851-52. He arranged the cylinders with a back-acting motion in a manner which anticipated the type of engine afterward bearing his name. The device showed his mechanical ingenuity, although the vessel as a whole was not a success, and the experience taught him in future designing to provide engine frames strong enough to allow for weakness in the hull, a point which was especially important when so many old vessels, many of which were of light construction, had to be equipped during the Civil War.

At the outbreak of the Civil War, Isherwood, although some distance from the top of the list, was appointed to the responsible position of engineer-in-chief of the war navy. His appointment was dated Mar. 26, 1861. Not only did he evince a dependable zeal for the Federal Government—which, at a time when so many officers were going over to the Confederacy or wavering in their allegiance, was no small recommendation—but his professional qualifications were of an exceptionally high order. For many years past he had given his attention to systematic experimental research in steam engineering, where he had done splendid work and was probably the leader in America. The result of some of these researches had been given to the public, notably in 1859, in a book entitled "Engineering Precedents," which embodied his studies on the indicated power of engines, frictional losses, power expended in actual propulsion of vessels, etc. It is interesting to note that this book had the first published indicator diagrams reproduced from actual engines.

The task confronting Isherwood upon his appointment was that of evoking a new and large navy out of nothing, or next to nothing, in a short period. At the beginning of the war the Government had only 69 vessels of all classes, 34 of them being sailing ships. By the end of the year 1861 it had improvised a navy amounting to 211 vessels, with 2301 guns and 20,000 men, which by the close of the war had grown to 600 vessels of all classes.

One of the reasons for Isherwood's success was his strong common sense, which was shown particularly in the design of the machinery built during the Civil War. Although the adoption of a low ratio of expansion, and hence high mean pressure, gave him small engines, the machinery was very heavy. Designers working 30 or 40 years later, with improved materials, have criticized this machinery, forgetting one point with which Isherwood was supreme—this machinery was designed for war vessels, and it was absolutely essential that it should not break down. The enormous expansion of the Navy led to the employment of large numbers of patriotic but comparatively unskilled engineers. To have intrusted delicate machinery to such men would have been to run the risk of disaster. For the same reason, such expansion as was obtained depended only on the ordinary Stephenson link, there being no separate and complicated cutoff gears. But almost incredible was his ability to find time for the continuation of elaborate scientific investigations, to profit by his unrivaled opportunity for practical experiments, and even during those busy years to publish in huge volumes the results of his researches.

In 1863, when swift cruisers were coming into use, speed qualities received especial attention. About this time the rivalry in design between Isherwood and Ericsson was carried out in the construction of twin 4200-ton ships—the "Madawaska," with engines of Ericsson's design, and the "Wampanoag," fitted with Isherwood engines. The latter had a pair of 100-in. cylinders with 4-ft. stroke and wooden gears, to make 2.04 revolutions of the screw for each double stroke of the piston.

Here, again, we note an illustration of Isherwood's sound common sense. The machinery, which for the time was extremely powerful, was to go into a relatively light wooden hull, and to have used direct-driven engines would have racked the hull. Ericsson's engines were of the same size, but directly connected to the shaft. In the trials the "Wampanoag" made a wonderful record for those days, attaining an average speed of over 16 knots in a winter's sea, and during several periods of a six-hour run over 17 knots were obtained. The "Madawaska" also was capable of high speed, but she could not stand the racking. This did not disprove Ericsson's essential correctness in having, long ago, come out as an advocate of direct, ungeared connections, but the abnormal narrowness of the vessel created a special condition to which the design of her machinery was not adapted. Not for 21 years was the "Wampanoag's" speed again reached in the Navy.

In the early personnel struggles, Isherwood was a champion of his corps. He contended that naval engineers required not only technical training, but theoretical education, and should possess official rank, which has since become established. It is largely to him that we may credit the Congressional Act of 1864 providing for the education of midshipmen as naval constructors or steam engineers.

After serving as engineer-in-chief for eight years, covering the stressful period of the war, Isherwood was succeeded, in 1869, by James W. King. The remainder of his term in the service was largely taken up with special duties. His experiments with screw propellers at Mare Island are scarcely less famous than the expansion tests and those on the economy of compound engines.

By operation of law he retired in 1884 with the relative rank of commodore (since raised to rear-admiral). More than a quarter of a century of life was still in store for him, however. He made his home in New York City, interested and active in research, scientific and literary work, and indulging in extensive tours abroad. The published output of his life in books and papers has been considerable. His "Experimental Researches in Steam Engineering," compiled in Civil-War times, has become a classic, and, as the late Dr. Thurston pointed out, "his conclusions, once ridiculed, are now the basis of the modern engineer's practice."

OBITUARY

BEN B. LAMPREY

Ben B. Lamprey died June 14, at the age of 68, in Westfield, Mass. He was born in Moultonborough, N. H., and in his younger days conducted a hotel and ran a steamboat line at Lake Winnepesaukee. He was the inventor of the Lamprey arch plate and of other devices for low-pressure steam boilers, and was the owner of the Lamprey Boiler, Furnace & Protective Co., of Boston.

PERSONALS

M. A. Hudson, formerly vice-president and general manager of the J. E. Lonergan Co., Philadelphia, Penn., has become general manager of the Central Western branch, United Roofing & Manufacturing Co., with headquarters in the Marquette Building, Chicago.

J. N. Oswald, formerly a member of the engineering department of the Pittsburgh Ry. Co., has been appointed mechanical engineer with the Vacuum Oil Co., Pittsburgh. He was the first erecting engineer of the Nagle Corliss Engine Works, of Erie, Penn., and was for 11 years at the head of the power department of the Gould Coupler Co., Depew, N. Y. Mr. Oswald is president of Pittsburgh No. 3, N. A. S. E.

Osborn Monnett, after a creditable service of four years as chief smoke inspector of the City of Chicago, has become associated with the Institute of Thermal Research of the American Radiator Co., Chicago. In this connection he will offer his services to smoke commissions and smoke inspectors throughout the United States and in every way possible cooperate with those interested in the movement to standardize smoke ordinances and to abate the smoke evil in the heating field. Mr. Monnett was an associate editor of "Power" before taking the Chicago position.

ENGINEERING AFFAIRS

The Canadian Association of Stationary Engineers will hold its annual convention July 20-22, at Hamilton, Ont. It is expected that the attendance of delegates and the display of exhibits will be larger than ever before. The local committee, with the assistance of the officers of the Exhibitors' Association, has arranged an enjoyable entertainment program.

The New England States Association of the **National Association** of Stationary Engineers will hold its annual convention in Holyoke, Mass., July 7-10. The Nonotuck Hotel has been selected as the headquarters. The meetings of the delegates will be held in the large hall of the Temperance Building, and the City Hall has been secured for the exhibits. An enjoyable program of entertainment has been arranged by the local engineers' committee and by a committee of the supplymen.

TRADE CATALOGS

International Nickel Co., 43 Exchange Place, New York. Catalog. Monel metal. 12 pp., 4x8½ in.

General Electric Co., Schenectady, N. Y. Bulletin No. 42,552. Motor generator sets. Illustrated, 28 pp., 8x10½ in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin 34-X. Class A-G "Giant" gas and gasoline engines. Illustrated, 8 pp., 6x9 in.

Fisher Governor Co., Marshalltown, Iowa. Bulletin Catalog. Pump governors, reducing valves, pressure regulators, etc. Illustrated, 6½x9½ in.

Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3031. Ingersoll-Rogler Class FR-1 air compressors. Illustrated, 24 pp., 6x9 in. Form No. 4034. Leyner-Ingersoll water drill. Illustrated, 4 pp., 6x9 in.

A. S. Cameron Steam Pump Works, 11 Broadway, New York. Bulletin No. 104. Station and sinking pumps. Illustrated, 36 pp., 6x9 in. Bulletin No. 150. Double suction volute centrifugal pumps. Illustrated, 16 pp., 6x9 in. Bulletin No. 151. Turbine centrifugal pumps. Illustrated, 20 pp., 6x9 in. Bulletin No. 152. Single suction volute centrifugal pumps. Illustrated, 8 pp., 6x9 in. Bulletin No. 153. Centrifugal pumps for house service. Illustrated, 8 pp., 6x9 in. Bulletin No. 300. Triplex pumps. Illustrated, 4 pp., 6x9 in.

NEW EQUIPMENT

ATLANTIC COAST STATES

Bids will be received until 2:30 p.m., June 29, by E. S. Elwood, Secy., State Hospital Comn., Capitol, Albany, N. Y., for the construction and equipment of a power house and electrical work at the Middletown State Homeopathic Hospital, Middletown, N. Y.

The Board of Education, Paterson, N. J., has engaged Lewis E. Eaton, Consult. Engr., to prepare plans for a light and power plant for the High School. An appropriation of $5000 has been made for the work.

SOUTHERN STATES

An election will be held June 29 in Orangeburg, S. C., to vote for a bond issue of $15,000, the proceeds of which will be used for the improvement of the municipal electric-light plant. Edward Howes is City Engr.

The City Council of Cordele, Ga., will engage an engineer to prepare plans and estimates for the construction and operation of a municipal electric-light plant in Cordele.

At a recent election the citizens of Toccoa, Ga., voted in favor of issuing $35,000 in bonds to be used for the installation of a municipal electric-light plant.

CENTRAL STATES

The Falls Rubber Co., Cuyahoga Falls, Ohio, is having plans prepared for a one-story brick and steel power house for its plant. Ernest McGeorge, Leader-News Bldg., Cleveland, is Engr.

It is reported that the Ohio Public Utilities Commission has authorized the Dayton Power & Light Co., Dayton, Ohio, to issue $172,000 in additional capital stock, the proceeds of which will be used to increase the output of the plant from 20,000 to 30,000 hp.

The City Council of Wellsville, Ohio, will soon advertise for bids for the sale of $60,000 in bonds, the proceeds of which will be used for the construction of a municipal electric-light plant.

It is reported that bids will be received until July 12 by the Wernette-Bradfield-Meade Co., Arch. and Engr., Grand Rapids, Mich., for the construction of a power plant for the Imperial Furniture Co., Grand Rapids.

It is reported that the City of Petoskey, Mich., is preparing to rebuild the municipal electric-light plant. J. W. Lovelace is Mgr. and Supt.

The Town of Three Rivers, Mich., is reported to have $50,000 in bonds available for the construction of a municipal electric-light and water-works plant. George Champe, Toledo, Ohio, is Consult. Engr.

WEST OF THE MISSISSIPPI

It is reported that the Des Moines Electric Co., Des Moines, Iowa, contemplates the construction of a 44,000-volt transmission line to Knoxville, Iowa, to furnish energy to the Knoxville Electric Co.

(Official)—Bids will be received until July 1 by the City Council of Davenport, Neb., for the installation of an electric-light plant to cost about $5000. Charles F. Sturtevant, Holdrege, Neb., is Consult. Engr. Noted June 22.

The City Council of Holdrege, Neb., has extended the franchise of the Holdrege Lighting Co. for a period of 25 years. The company has agreed to reduce its rates for lighting and will make various improvements in its plant.

The Union Light, Heat & Power Co., Fargo, N. D., is enlarging and improving its power station, and will install new equipment, including two 1500-kw. steam turbines, two water-tube boilers, a three-unit motor generator set of 600 hp., boiler feed pump, exciters, switchboard, etc. M. L. Hibbard is Mgr.

(Official)—Bids will be received until 2 p.m., July 15, by John A. Ryan, Secy., Bd. of Pub. Wks., Chillicothe, Mo., for installing in the municipal electric-light plant the following equipment: One 375-kw., three-phase, 60-cycle, 2300-volt generator, direct-connected to a steam engine or steam turbine to operate condenser, with separate exciter, switchboard panel and instruments, power circuit panel, etc.; one 500-g.p.m. motor-driven centrifugal pump, for use with condenser, and one 12-in. barometric condenser, one 12-in. horizontal oil separator, and the necessary pipe, valve fittings, etc., required to install the pump and condenser. Harper & Stiles, Grand Ave. Temple, Kansas City, is Consult. Engr.

The Missouri Public Utilities Co., Cape Girardeau, Mo., has been granted a franchise to construct a transmission line from its power station at Charleston, Mo., to East Prairie, a distance of 12 miles, to furnish electrical service to the latter place.

It is reported that H. W. Wright and Thomas Peterson, both of Peoria, Ill., are considering plans for the installation of an electric-light and power plant in Fulton, Mo. Energy for the operation of the plant will be obtained from the Keokuk Electric Co., Keokuk, Iowa.

Henry S. Grimes has made application to the City Council of Lowry City, Mo., for a franchise to install an electric-light plant in Lowry City.

It is reported that the City of Brownsville, Tex., is considering the sale of the municipal electric-light plant to a company which will also take over the street-railway company and combine the two properties. J. W. Davis is City Engr.